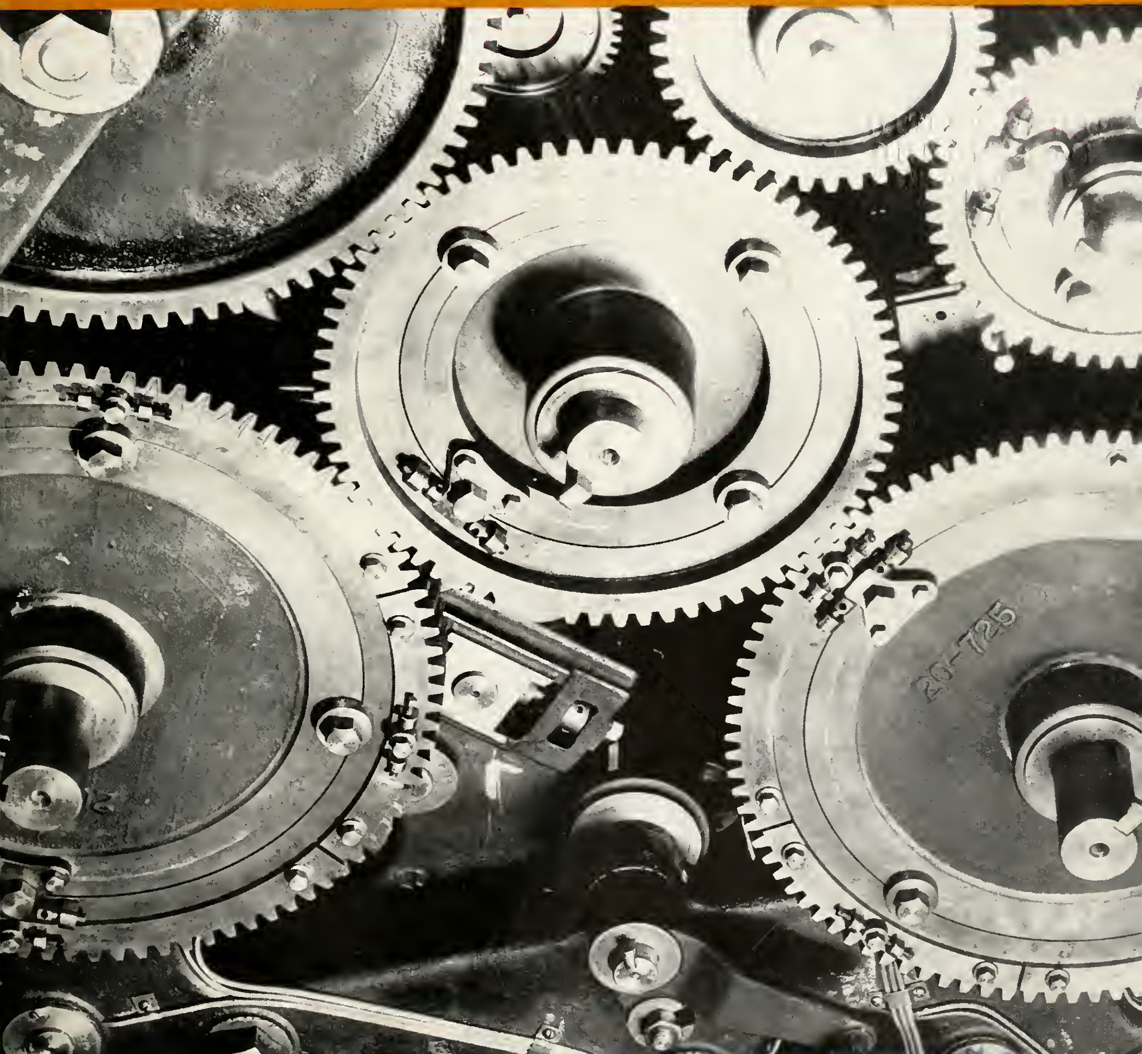
ILLINOIS TECH ENGINEER



OCTOBER, 1946

68036

Wilbur Wright
1867-1912

THE WRIGHT BROTHERS

Orville Wright
1871-

The Wright Brothers were co-workers in the finest sense of the word, engaging in research work and study of every scientific phase of airplane construction.

Their success came when they made their first flight forty-three years ago on December 17, 1903, after careful study, endless experimentation and repeated disappointments.

But theirs was a spirit that persisted through time and discouragement, a spirit that carried them on to repeated efforts and hence to realization of that long cherished dream.

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IN THIS ISSUE

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See CONTRIBUTORS on page 4

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John T. Rettaliata is Professor of Mechanical Engineering and Director of the Department. He has the degrees of B.E. and D.Eng. from Johns Hopkins University. A major part of his engineering work has been with steam and gas turbines, and before joining the Institute faculty in 1945 he was manager of the Research and Gas Turbine Development Division of the Steam Turbine Department of Allis-Chalmers. Dr. Rettaliata has published many articles. He received the ASME Junior

See CONTRIBUTORS on page 38

Lithography Comes Of Age

By WADE E. GRISWOLD

Lithography has become one of the principal means for channeling ideas and information to the public. Its sudden growth in the past twenty years has been so spectacular that science and other industries have reason to be interested.

That scientific research played an important part is evident. The factors and circumstances seem to be revealed in the relationship of the development to trends in public and industrial thinking.

The growth of lithography from an art to a craft, to a mass production ink-on-paper medium now often employing line production techniques, would appear important to research men who have despaired of developing private or cooperative research programs and projects for industries that have not sprung from sciences.

Here is what Dr. Jewett, President of the National Academy of Sciences, said at the opening of the new Sugar Research Foundation regarding the problems of setting up cooperative programs, such as exist in the lithographic industry today:

Measuring pH of Fountain Solution.

"One of the first things that I noticed in the early days of my career in industrial research was that it was very much easier to bring the tools and methods of fundamental science as exemplified in the laboratories of universities, technical schools, foundations and what not to the assistance of industries which had developed out of modern science than it was to industries which were old in human history —that is, to industries which had grown out of ancient arts.

"If you will look back you will find that the first great industrial research laboratories were in the fields of modern chemistry or of physics primarily as exemplified in the electrical industries. In other words, in those industries which in effect grew out of laboratory work rather than out of an art as slowly developed through human experience. Also you will find that generally speaking those industries which are oldest in human affairs and whose

methods have evolved slowly from their beginning in prehistoric times were the slowest and most conservative when it came to adopting the methods of the newer science.

"True, they rather early adopted some of the elementary tools of science for check and control of processes. Likewise, they were not slow to employ technology for labor-saving purposes as a means of lowering costs. But as for using science largely as a primary tool they have been slow despite the fact that potentially they have the most to gain since because they deal with man's primary wants they are concerned with his principal activities.

"While it is a curious phenomenon it is not a surprising one when we stop to think of man's conservative tendency to cling to the pattern of his past experience. The more each new generation is schooled mainly by apprenticeship to the preceding one the more conservative it will be."

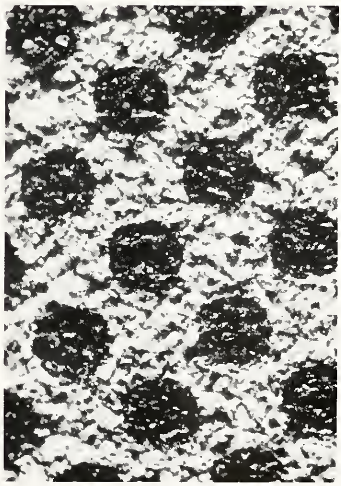
Perhaps it would be an error to label the lithographic process an art in the sense that Dr. Jewett uses it merely because it has so long been associated with the reproduction of art subjects. In reality its inventor, Alois P. Senefelder, developed the process a hundred and fifty years ago from the simple, scientific fact that grease and water do not normally mix.

The process as used today is essentially the same as when he developed it in 1796. A printing surface is employed whose non-printing areas are dampened to prevent greasy ink from adhering to them, the image on that surface is receptive to greasy ink, and the ink image is transferred to paper.

But first a brief summary of the three principle printing processes, neglecting large areas of their history and much that is of technical interest, may throw into relief the unique characteristics of lithography and its development from Senefelder to modern production methods.

Letter press printing has a long and honorable history. Printing by transferring ink from a raised surface to paper, like many of the arts of man was known in China centuries ago. The invention of movable type made possible the printing of books. The invention of the half-tone process gave the printer, in addition to photographically produced replicas of line drawings, reproduction in tone of photographs and drawings.

By means of a fine ruled screen in the camera in optical relationship to the lens and its diaphragm and the photographic emulsion, the tones of the original print are translated into so-called dots of varying areas. A light sensitive resist on a zinc or copper plate, after exposure and development permits, with considerable hand work, etching of the metal: and dots of variable area are produced, which when transferred to paper by the printing process are translated by the eye into a replica of the original print.



200-line deep-etch plate, estimated estimated 40 per cent density. (100x).

Photographic means for separately recording three substantially equal portions of the visible spectrum, again through the half-tone screen, enable successive printing of colors secondary in relationship to the primary color separation, and a replica in color of the original.

In the press, considerable pressure and control of pressure by mechanical means, the use of "make-ready" — overlays on the pressure cylinder, underlays below the type or plate — is necessary for satisfactory prints.

Rotogravure is a development of the process wherein the artist scratches lines through a resist on a copper plate, etches depressions in the metal, applies ink to the plate, cleans the unetched portions of the plate, leaving the ink in the depressions, and transfers the ink by pressure to paper.

In rotogravure the photographic image is printed on a resist through a ruled screen which divides the print area into small square cells of equal area separated by fine lines. The copper cylinder is etched through the developed resist—not at all on the lines, through varying thicknesses of resist on the cells and to varying depths on the cylinder. When ink is applied to the cylinder and wiped off from the unetched lines by a flexible steel blade, cylinder pressure deposits varying thicknesses of ink on the paper, thus reproducing the tones of the original by dots of equal area.

Recent developments in rotogravure have added invert halftone — intarprint, with variable area — or with both variable area and variable depth as in the Doeltgen and Sportelli processes.

Lithography is a planographic process, as contrasted with the relief printing of letter-press and the intaglio printing of rotogravure. The image or work area is receptive to greasy ink, the non-work area retains water which repels greasy ink; and the work area and the non-work areas are substantially in a plane.

As in letterpress and unlike rotogravure, line can be reproduced without the use of a screen. Reproduction of tone and reproduction of color by successive printings employs the variable area dot of the half-tone process. But here the resemblance ceases.

In lithography, after exposure of the negative, dot etching on negative or positive controls tone by chemical means. The dot etcher works not on metal but on the photographic emulsion. When the sensitive emulsion on the metal plate is exposed through

negative or positive and the plate is processed ready for the press, tone control and color control is virtually complete.

On the press, from printing plate to final product on paper, mechanical control of print quality is reduced to a minimum, and chemical control largely governs.

Dampening of the plate, deposition of the optimum quantity of water on the grained non-work areas by means of rollers, is largely controlled by the pH of fountain fluid and "desensitizing" materials such as gum arabic. The plate cylinder carrying the plate thus dampened, then brings the plate into contact with the ink rollers. Contact between the plate cylinder and the rubber blanket cylinder, because of the planographic nature of the plate, is a mere "kiss pressure," and make-ready in the letterpress sense is non-existent. Again, contact between the blanket cylinder and the paper on the impression cylinder is slight and subject only to overall control.

Zinc or aluminum is used in two general types of printing plates:

In the albumin plate, dichromated egg albumin is coated and dried by whirling. Exposure through the negative and development to remove the unexposed colloid leaves work areas of hardened albumin, which are ink receptive.

In the deep-etch plate, a dichromated gum arabic coating is exposed through a positive and developed, leaving work areas of clear metal. Etching slightly below the top level of the grained plate provides anchorage for a suitable lacquer; and gum arabic and excess lacquer are removed, leaving the work-area lacquer, also ink receptive, more firmly attached to the plate than is the surface-attached albumin work-area.

Returning to the development of lithography, there have been many adjustments in techniques, skills, equipment, and materials as changes occurred in public tastes and trends. These have been concurrent with new mechanical and chemical methods and applications.

Lithography had a slow but steady growth from an individual art to a craft in its first one hundred years up to the turn of this century. In that time it served largely a trend which provided art and music for the masses at lower cost through reproduction of originals. Public demand for illustration in news and product information from the Civil War on was parallelled by expansion made possible by mechanical means of increasing rates of production. Early in this century when modern advertising techniques were born, it began to serve the mass marketing and distributing systems accompanying the mass production of consumer goods.

When lithographers felt the pressure of increased production demand some fifty years ago, they abandoned flat-bed presses and the vein of Solenhofer stone first used by Senefelder and by lithographers ever since; they turned to science and found a substitute in grained zinc. The surface, being increased four or five times by mechanical graining, holds the moisture essential to the operation of the process by capillary attraction rather than absorption. Aluminum, stainless steel, monel and bi-metallic plates came later. The effect of this change was to open the minds of lithographers to scientifically developed ideas, and this condition has continued.

The industry and technical development have been held closely together because the process is essentially chemical throughout, whereas letterpress printers are more concerned with mechanical means of tone correction, make-ready, and pressure. The latter have split into separate businesses: typographers, platemakers, electroplaters, varitypers, and printers. Lithographers have kept greater control of their process. They generally make and run their own plates. The reverse is true of letterpress.

The thin zinc plate can be wrapped around a cylinder on the faster rotary press as contrasted with the slow flatbed, horizontal motion that served the "stone age" in lithography. The process still remains essentially planographic and keeps the advantage of large printing areas with very little make-ready on the press.

Mechanical engineering developments which played such an important part in the growth of the American mass production system were not at first easily sold to the tradition-bound art and craft lithographers, either in the metal decorating or paper printing trades. But there was pressure from consumer goods manufacturers using modern advertising tools to develop markets. They wanted posters, calendars, can and food package labels with color, and product illustrations and information to attract attention, arouse interest, create demand, and produce buying action. Lithographers met the demand.

When advertising art taste veered from artists' conceptions to photographic reality, influenced perhaps by the motion picture, the days of the litho artist who created design on stone by crayon and stipple were numbered in many plants. But it was some time before science could apply photographic transfer methods to lithography against the traditional art and craft opposition of hand transfer and other lithographic craftsmen. This is the only point at which science might be accused of having retired lithographic skilled craft manpower a little too fast, although most of the men were retained for other litho jobs.

When photographic methods were being accepted generally, those who were lithographing on paper borrowed the method prevailing in metal decorating. Instead of printing direct, this called for offsetting the image on a rubber blanket mounted on a cylinder of a rotary press and thence on the paper.

All these ideas were being discussed, investigated, and developed when the first World War came along. As an outcome of it, the importance of organized research laboratories was shown—such as came to the fore in the electrical and chemical industries, which had grown from sciences. The majority of military maps always having been lithographed, the lithographic industry was close to war activities.

It was natural that immediately after the war a number of far sighted lithographers and their suppliers began to explore the possible benefits of scientific research. The lithographic

See LITHOGRAPHY on page 44

OUTSTANDING FIRE CAUSES AND LESSONS THEY TEACH

By JOHN J. AHERN

Today, after seventy-five years of increasingly intense fire prevention activity, our foe, the destroyer of our national wealth, seems to be catching his breath for a renewed onslaught. Looking at the record we seem to be losing ground and tiring in our efforts as fire tears out great chunks of our economic structure at a particularly critical time. In addition there is an uncomfortable feeling that perhaps we are shirking our duty in this respect. All of us in the loss-prevention profession carry a heavy responsibility towards our fellow citizens. They look to us to keep their homes, their families, their children, and their places of employment safe from harm. From the standpoint of industrial safety we can afford to feel proud of our accomplishments; however, if we look at the fire prevention phase of our responsibility we must hang our heads in shame. Our efforts in industrial safety have produced a steady downward trend in frequency rates which even resisted the impact of a war and the greatest expansion ever experienced by industry. In the meantime, however, the fire loss has been mounting. The year 1935 marked the end of a downward sweep which carried us to a low in our fire losses of \$235,263,401. Slowly and relentlessly this national scourge has been creeping up on us until at the end of 1945 it had reached the appalling figure of \$484,000,000. Its advance has not been stopped! The toll for this year is almost thirty per cent higher than in the similar period of last year. At the end of July this waste had reached a total of \$338,304,000 which exceeds the recorded loss for any calendar year from 1933 through 1942.

If we could excuse these mounting loss figures by charging them off to inflation the picture would not look so dark. We are all familiar with the painful fact that the item which could have been replaced five years ago for ten dollars will now cost fifteen or twenty, if available at all. This situation, undoubtedly, is partially responsible for the mounting losses; however, careful investigation shows that only a very small part of the increase can be honestly charged to inflation. For example, the records of our own Chicago Fire Department show a 28.2 per cent increase in alarms during the first eight months this year over last. Here there is no question of inflation —it is simply more fires. Furthermore, a study made by the National Board of Fire Underwriters shows that the upward trend still prevails when measured in terms of goods and property actually destroyed. In addition to the professional black mark against us, it is also true that this is the worst possible time in our history for fire to take its toll. All industry is engaged in a breathless race against inflation, to produce consumers' goods to soak up the excess purchasing power running rampant in the country. Each item burned, each building destroyed, is a backward step in the race against inflation. Those items are irretrievably wasted and contribute to the inflationary pressures.

Now to get down to the purpose of this paper: What are the predominating causes contributing to this national disgrace? Are they controllable? What can *we* do to stop this upward trend?

First of all, what is a fire cause?

Our statistics on fire causes are not completely reliable. First there is a great deal of muddled thinking on the subject which tends to confuse causes and media; to fail to distinguish between the source of ignition and the material which burns. For example, you very often hear that a fire was caused by flammable liquids and find that given in statistical tables as a fire cause. Actually, flammable liquids by themselves do not start fires but only contribute to the severity of the fire. The tragedy of such thinking is that the real culprit goes undetected; the faulty switch, open flame, or spark producing device which ignited the fumes is not properly engineered. The other and greater difficulty in collecting accurate cause data is the nature of the beast itself. Unlike most other accidents, fire frequently destroys all the evidence pointing to its origin making it extremely difficult to "reconstruct the crime". However, we do have a great deal of data and must make the best of the material at hand.

I have selected five causes which I considered outstanding because of the number of fires attributed to them and also because of the fact that they present problems which can be solved within the realm of our present knowledge. It would be thrilling to come before you and be able to say that the increase in fire losses is due to the use of atomic energy, jet propulsion, gas turbines, or some other startling wonder of the post-war world, but such is not the case. The increase is due to the same old faults which we have been fighting for many years, made more

serious and reinforced by lack of interest in the menace on the part of the general public.

Number one on the list of public enemies is our old problem child, smoking and matches. Each year since the turn of the century and particularly since World War I, the percentage of fires due to this cause has been rising. Here is a national monument to the efficiency of modern advertising. Millions of dollars have been spent convincing the American public that they should walk a mile for a cigarette, that they can get a lift with a smoke, that a particular cigarette satisfies, or that they should not be irritated, just light an el Ropo. Nowhere have I seen an advertisement reading, "Burn your house down with a Nicotino" or "Toast in bed with a fresh, cool Ignito". Yet our statistics tell us that such advertising would not be misleading. Please understand I am not objecting to smoking as such nor to the terrific advertising job which has been done. I am merely calling attention to the fact that we have created a public habit without regard to the precautionary measures which should accompany the habit. You have all had the experience of walking onto a beautiful ball room floor and suddenly noticing the burned marks, charred spots, which covered the floor. Each was a potential fire, an indication that the perpetrator had no regard for the damage being done. Another factor is the increase in women smokers. It was serious enough when we had only the men to worry about, but now the women smokers put them to shame. No bridge table is complete without four or five cigarette burns, mute evidence of potential fires which will reoccur. Here is a great opportunity for public education; the same medium which planted this habit can and should conduct a campaign to help its devotees pursue the habit in safety.

We must face it: smoking is a national habit. Acceptance of that fact brings us to the methods of controlling it. First and foremost is the provision of safe locations in which to smoke, rooms with a minimum of combustible furnishings, equipped with receptacles specifically designed for the safe disposal of matches, cigarettes, cigars, and ashes. There is a tremendous difference between an ash tray which permits the cigarette to topple out as it burns down and one designed so that it falls into the receptacle as it burns. Industrial establishments have learned that it pays to provide for safe smoking rather than to try to enforce impractical smoking regulations which breed stolen smokes and hasty disposal of lighted matches and cigarettes. Of course, we all realize that there are certain areas containing hazardous materials in which smoking must be forbidden. However, safe smoking facilities can be provided near-by, as was done in many explosives plants during the war, allowing the workers an occasional smoke without endangering their lives or the safety of the plant. In this connection, special attention must be devoted to contaminated clothing. The presence of oil, grease, explosive dusts or active oxidizing agents on clothing can turn a worker into a human torch as he lights his cigarette. The provision of permanent electric lighters helps to discourage the carrying of matches in work clothing. Our whole approach to the industrial problem of smoking should be one of intelligent cooperation rather than repressive regulations. The problem of domestic or personal smoking, however, is much more difficult to control. Here our only approach is that of education. In spite of the almost daily news accounts to the contrary, most people do not consider it dangerous to smoke in bed. This is a public education problem and one which calls for the greatest efforts of our advertising specialists. We must get across to each and every smoker the dangers involved and make safe smoking habits just as automatic with him as his smoking itself.

The next in importance among the sources of fire, because of the great monetary loss chargeable to it, are exposure fires, fires originating off the premises. Here the severity is all out of proportion to the number involved because each represents a fire which is, at least momentarily, out of the control of the fire department. Here is a cause that, from an engineering standpoint, is inexcusable. These fires cannot be blamed on carelessness, human habits, or sudden human impulses. Each fire started by exposure is a direct indictment of the engineers involved. In every case it was possible to foresee exactly what would happen before the fire in the adjoining property started. We knew what was required to confine it but the proper engineering steps were not taken. What are our weapons against this cause? First, there is no adequate substitute for open space between buildings. Not only does open space free of combustible material constitute a barrier to the passage of fire but it also provides space for the fire department to get in and make a stand. If open space is unobtainable a fire wall with no openings and extending through the roof with a parapet is our next defense. A good twelve-inch brick wall of this type will stop practically all fires long enough to enable the fire department to bring the spreading fire under control. As the protection decreases from the absence of these two most desirable features, we must make compromises. Walls with openings must be protected by automatic fire doors in operating condition, windows can be provided with outside sprinklers or equipped with wired glass in metal sash, and inside sprinklers provided for the contents. These compromises, however, will not hold back the spreading fire indefinitely, and the fire department will not have the margin of time provided by open space and blank walls. All of our cities are contemplating action in rehabilitating slum areas. The lack of open space, in addition to being a conflagration breeder, is the chief reason why exodus to the suburbs has occurred, producing decrease in property values within the cities. As slum clearance proceeds and long-range city planning is developed, we must see to it that adequate open space is made an integral part of each plan and thus stop at the source the number two fire cause.

The misuse of electricity is number three on the list of fire criminals. Here is another illustration of man's tech-

See FIRE on page 32

LINEAR RELATIONSHIPS IN GAS TURBINES

BY JOHN T. RETTALIATA

Much information is being published currently concerning gas turbines. The cycles that are being presented range from the basic arrangement, comprising a single turbine, compressor, and combustion chamber, to more elaborate cycles involving reheat, intercooling, and regeneration. The design and performance calculations associated with such cycles can become quite involved, and in order to assist in such endeavors and reduce the labor involved, set forth here are some linear relationships, characteristic of gas turbines, which may be found useful.

Since the motive fluid of practically all open cycle gas turbines is essentially air, the material contained herein is presented on that basis and perfect gas relationships are employed. Corrections for fuel additions are incorporated insofar as quantity is concerned, but the specific heat of the products of combustion resulting from the burning of the fuel is assumed to be the same as that of air. Air data have been obtained from "Thermodynamic Properties of Air", by Keenan and Kaye, with modifications to achieve linear relationships in certain instances.

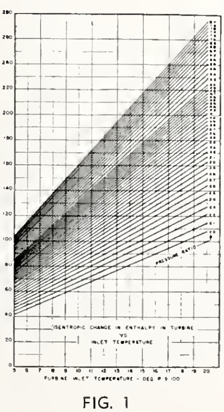


FIG. 1

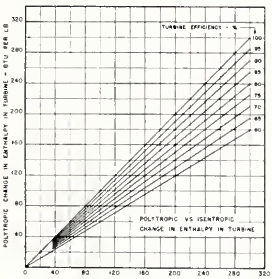


FIG. 2

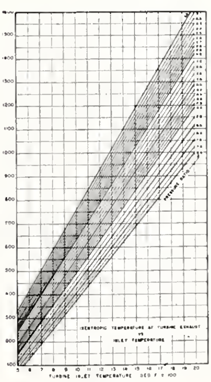


FIG. 3

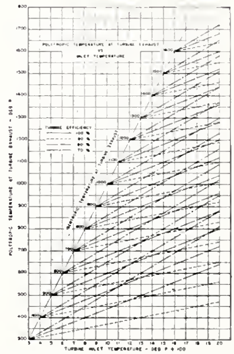


FIG. 4

Turbine

For a given pressure ratio, the isentropic change in enthalpy occurring during expansion in a turbine is a linear function of turbine inlet temperature for fixed values of isentropic exponent and gas constant. Figure 1 gives such values of enthalpy changes for pressure ratios of 2 to 8 and turbine inlet temperatures from 500 to 2000 F.

The polytropic change in enthalpy in the turbine is equivalent to the isentropic change multiplied by the turbine efficiency. Figure 2 gives polytropic changes as linear functions of the isentropic for turbine efficiences of 60 to 100%.

The turbine exhaust temperature at the end of isentropic expansion is a linear function of inlet temperature for a given pressure ratio and constant isentropic exponent. Values of the isentropic temperatures at the turbine exhaust are given in Figure 3 as a function of inlet temperature for various pressure ratios from 2 to 8.

The change in temperature during polytropic expansion is equal to the isentropic change multiplied by turbine efficiency. The polytropic change subtracted from the inlet temperature

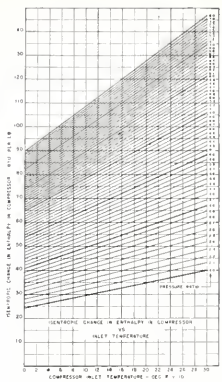


FIG. 5

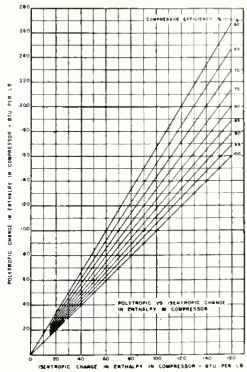


FIG. 6

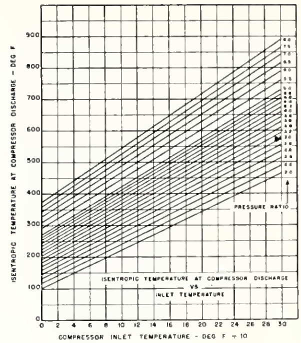


FIG. 7

will give the temperature at the end of polytropic expansion. Figure 4 shows the linear variation of polytropic exhaust temperature with inlet temperature for turbine efficiency of 70 to 100% and values of isentropic temperature at the turbine exhaust ranging from 300 to 1600 F. For ease in reading the chart it will be noted that corresponding efficiency lines are parallel to each other.

Compressor

As in the case of the turbine, the isentropic change in enthalpy during compression may be expressed as a linear function of compressor inlet temperature, and Figure 5 shows such values for pressure ratios from 2 to 8 and inlet temperatures of 0 to 300 F.

The polytropic change in enthalpy during compression equals the isentropic change divided by adiabatic compressor efficiency. Figure 6 shows the polytropic change as a linear function of the isentropic for compressor efficiencies of 60 to 100%. The polytropic change in enthalpy is required in order to determine the power required to drive the compressor.

Also, as in the case of the turbine, the temperature at the compressor discharge after isentropic compression is a linear function of the inlet temperature for a given pressure ratio and isentropic exponent. Values of the isentropic temperature as a function of inlet temperature for pressure ratios from 2 to 8 are given in Figure 7.

The change in temperature during isentropic compression divided by the compressor efficiency gives the polytropic change. The latter added to the compressor inlet temperature will give the temperature at the end of polytropic compression. This polytropic temperature is shown in Figure 8 varying linearly with inlet temperature for values of isentropic discharge temperature from 100 to 800 F. and compressor efficiencies of 60 to 100%. All lines of corresponding efficiency are parallel to each other.

Combustion Chamber

By burning fuel in the combustion chamber, heat is transferred to the motive fluid and a change in its enthalpy results. The enthalpy of air as a linear function of temperature for temperature ranges of 0-500 F., 500-1000 F., 1000-1500 F., and 1500-2000 F. is given in Figures 9, 10, 11, and 12, respectively. The increase in enthalpy effected in the combustion chamber is the difference in enthalpy at the entering and leaving temperatures. Since it is assumed that the products of combustion have properties similar to

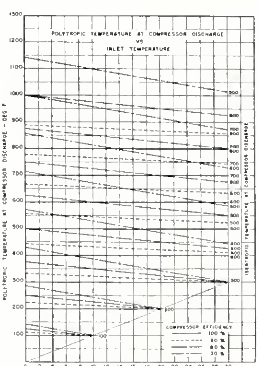


FIG. 8

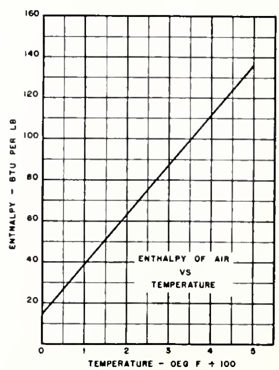


FIG. 9

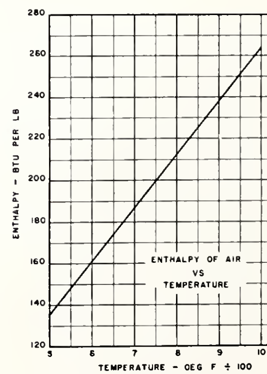


FIG. 10

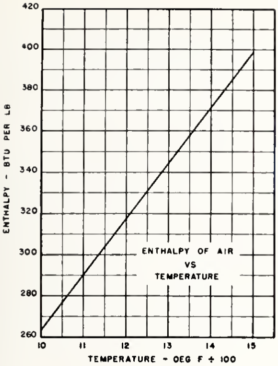


FIG. 11

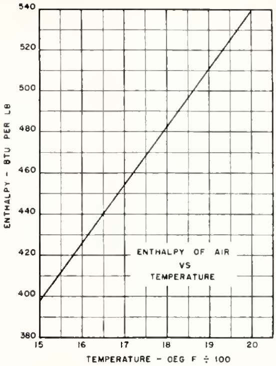


FIG. 12

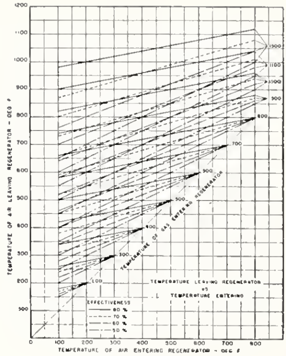


FIG. 13

those of air, these figures can be used for enthalpy of the motive fluid.

Regenerator

One of the most direct methods of increasing the thermal efficiency of a gas turbine cycle is by using a regenerator whereby the turbine exhaust gases are used to preheat the compressor discharge air before the latter enters the combustion chamber.

Figure 13 shows the temperature of the preheated air leaving the regenerator as a linear function of the temperature (compressor discharge temperature) of the air entering. Regenerator effectiveness of 50 to 80% and entering gas temperatures (turbine exhaust temperatures) of 200 to 1200 F. have been used. Lines of corresponding effectivenesses are parallel to each other.

Intercooler

Increase in thermal efficiency can also be accomplished by employing an intercooler between compression stages and thereby reducing the work of compression. The coolant, usually water, in the intercooler reduces the specific volume of the air and, in turn, the power required to compress it.

In Figure 14 the temperature of the air leaving the intercooler is shown to vary linearly with temperature entering, for coolant temperatures of 40 to 80 F. and intercooler effectivenesses of 50 to 80%. Lines of corresponding effectivenesses are parallel to each other.

Fuel Consumption

The specific fuel consumption as a linear function of heat input from the fuel is given in Figure 15, for lower heating values of the fuel ranging from 5000 to 20,000 Btu per pound. This range is sufficiently broad to include both solid and liquid fuels. The heat input is equivalent to the change in enthalpy, in Btu per pound of motive fluid, occurring in the combustion chamber and may be determined from Figures 9 to 12. The heat input is the quantity of heat from the fuel added to each pound of motive fluid (including combustion products) passing through the turbine. Thus the fuel quantity is included on the basis that the specific heat and heating temperature range of the fuel are the same as that of the air.

The total fuel consumption is shown as a linear function of the specific fuel consumption for various motive fluid flows from 1000 to 12,000 pounds per minute in Figure 16. The motive fluid flow is equivalent to the quantity of

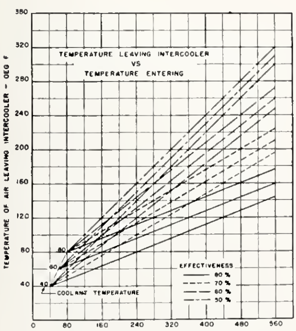


FIG. 14

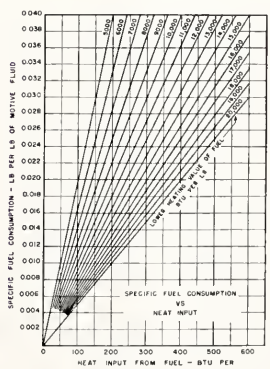


FIG. 15

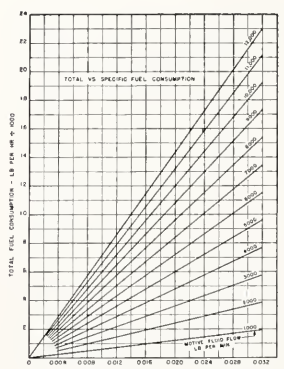


FIG. 16

air entering the compressor divided by the quantity one minus the specific fuel consumption.

Power

The horsepower developed by the turbine or required by the compressor is given in Figure 17 as a linear function of change in enthalpy for flows ranging from 10,000 to 150,000 cfm. The latter units have been employed since compressors are usually rated in volume flow but where required, a ready conversion from cfm to pound per minute and vice versa, can be made by use of Figure 18.

Referring to Figure 17, the power developed by the turbine may be determined by selecting the change in enthalpy from Figures 1 or 2, depending upon whether theoretical or actual power is required, and the appropriate flow line. In the case of the turbine, the flow is the actual quantity of motive fluid passing through it, including fuel.

The power required by the compressor may also be obtained from Figure 17 after the appropriate change in enthalpy has been obtained from Figures 5 or 6, and the proper flow line selected. If an intercooler is incorporated in the compression process, then the change in enthalpy will be the sum of that occurring before the intercooler and that after, the latter being obtained with the reduced temperature occasioned by the introduction of the intercooler.

The difference between the power developed by the turbine and that required by the compressor represents the useful output.

Thermal Efficiency

The thermal efficiency of a gas turbine cycle is given as a linear function of useful output in Figure 19 for various values of heat input ranging from 25 to 1000 Btu per pound. Since the useful output is expressed in B.T.U. per pound, its value may be determined by dividing the heat equivalent of the useful output in horsepower, as obtained from Figure 17, by the pounds of motive fluid producing it, both items being based on the same period of time. The heat input quantity referred to in Figure 19 may be found from Figures 9 to 12, as mentioned previously in the combustion chamber section.

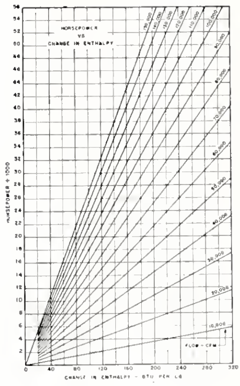


FIG. 17

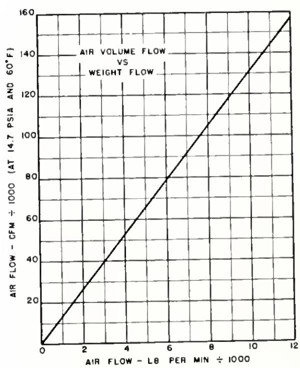


FIG. 18

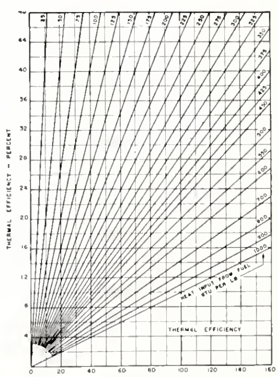


FIG. 19

Conclusions

It is believed to be of interest that, as has been demonstrated in the paper, the important variables of gas turbine cycles can be made to bear linear relationships with each other. To accomplish this in some instances, it has been necessary to assume the existence of constant specific heats and isentropic exponents. Notwithstanding such simplifying assumptions, however, the thermodynamic data presented agree within several per cent with those accepted as standard.

The normal methods used in the usual performance calculations of complicated gas turbine cycles are laborious, especially when a series of calculations is being made in an attempt to determine an optimum arrangement. The use of the graphical data presented here will greatly reduce the time required for cycle calculations and yield results accurate to within several per cent. In most cases, such a degree of accuracy will be acceptable, but where greater refinement is required, it will, of course, be necessary to account for all variations, including the actual composition of the motive fluid expanding through the turbine, the effect of the humidity of the air entering the compressor, etc. In the majority of cases, however, it is considered that the methods presented in the paper will be found useful.

In this study the upper temperature limit has been selected at 2000 F. While gas turbines actually operating at such a temperature are not known, this temperature was adopted so that calculations showing future trends and possibilities may also be performed. Rapid metallurgical advances have been made during the war and designs of gas turbines of appreciable size and service life in the 1500 to 2000 F. range will be forthcoming in all probability.

The possibilities of combining several of the graphs presented into convenient nomograms should not be overlooked, and their use will determine which combinations can be most beneficial.

A. R. F.

TECHNOLOGY

IN SELECTED MEXICAN INDUSTRIES

By MILTON E. NELSON

The contrasts in topography, climate, soils and resources of Mexico reflect her manner of living, industry, and technology. The topography varies from snow-capped peaks to broad open plains. The cool dry climate of the upper plateaus contrasts with the hot humid conditions of the tropics. Rainfall which increases the flow of the rivers of Quintana Roo to such an extent as to almost prohibit the development of railroads and highways has its opposite extreme in the dry desert Northwest, parts of which in some years will not experience a single shower. The soilless peninsula of a large part of Yucatan is contrasted to the heavy organic soils on the volcanic slopes of Chiapas. Mexico is both blessed and cursed with conditions which make for almost any desired type of agricultural and related industrial pursuit. Out of these extremes the present Mexico has developed and on them she proposes to build an industrial nation.

Drawing on the natural resources of the country the conquerors of the Aztecs began to gather in the wealth of the nation by drawing not only on the silver mines, but also by taking out precious woods, fibers, fruits, etc. Meantime the colonizers began cultivating the rich soil and bringing new industry into the country. Step by step one industry followed another to supply the needs of the colonizers and provide the nucleus of her present industry.

Silver has been, since Cortez rode into Mexico City, the major industry supplying a large part of the needs of the United States for this metal. Her oil production at one time ranked third among the nations of the world. It is the less renowned industries, however, upon which she intends to build her future. The technical evaluation of four of these industries was the objective of an extended survey made by Armour Research Foundation of Illinois Institute of Technology[1]. Various aspects of the industries of solid fuels, fibers, hides and leather, and forest products will be briefly discussed.

Solid Fuels

The vast developments of the petroleum industry subordinated the position of coal within the Republic. The nation's known coal deposits, which are in themselves quite large, have been almost completely ignored. Interest in them has centered in the nation's iron and steel industry which must have coke for its operation. Even these interests have failed to explore and evaluate the main deposits.

The use of petroleum fuel in industry is contrasted to the nation-wide domestic use of charcoal, which in the highly populated areas is rapidly depleting nearby forests. Efforts are being made to curtail the use of charcoal and replace the conventional charcoal grill with kerosene stoves. The ability to modify coal to produce a smokeless substitute, coke or semi-coke, that could be used in the charcoal stoves suggests an alternative by which the resistance of tradition could be overcome, at the same time avoiding the necessity of a sudden change to new methods of cooking which would be quite radical for the average Mexican cook.

As an industrial fuel, with suitable mining and processing, coal may provide an abundant source of energy without unnecessary depletion of the nation's petroleum reserves. The quality of the coal can be improved to give an ample reserve of high-grade coke required by the steel industry and at the same time provide valuable by-products.

Mexico has an adequate reserve of fuels which if properly processed can support a fairly large industrial program.

Fibers

The native desert plants of the large arid regions of Mexico have been exploited for the production of hard fibers. Chief among these are: hene-

[1] *Technological Audit of Selected Mexican Industries with Industrial Research Recommendations*, by Francis Godwin, Milton E. Nelson and Roberto Villasenor, Armour Research Foundation of Illinois Institute of Technology, 1946, Chicago, Illinois.

quen *(Agave fourcroydes)*, lechuguilla *(Lonphanta heterocantha)*, maguey *(Agave atrovirons)*, palma *(Samuela carnerosa)*, and zacaton or broomroot *(Epicampes macroura)*. Henequen and maguey have been cultivated, the latter for its juice (agua miel) which is the fermentation base for the national drink pulque, rather than for its fiber. Lechuguilla, palma and zacaton are harvested from the natural flora.

Typical desert area from which palma and lechuguilla are gathered for their fiber.

Certain parts of the vast desert areas have been reclaimed through irrigation. The Mexican government in particular has spent large sums of money in building dams and providing irrigation systems, thus bringing fruits, vegetables and industrial products from the great barren stretches of untilled land. Cotton to supply the textile industry is a product of these areas.

The fiber and textile industries were perhaps the first to be established on a large scale within the Republic. Today these activities constitute the largest single specific industrial group in the country and employ a total of over 78,000 persons. The majority of this group are employed within the cotton textile industry with lesser numbers in hard fibers and wool.

In the textile industry both extremes in manufacturing exist. In some areas the country is provided with the most modern automatic looms, yet it is not uncommon to observe hand spinning and hand weaving operations in home industries. Products of both are frequently seen side by side in the market.

Textiles produced in the more modern plants are for the most part competitive with imported products. The quantities available are altogether too small to meet the demand. In spite of efforts to obtain new equipment and to train personnel to operate the new equipment progress being made in this industry is far too slow. The inclusion of more highly trained technical personnel could contribute to accelerating the flow of improved materials to the market.

Mexico is one of the world's major producers of hard fibers, with henequen as her most important product. The industries in the Dutch East Indies, Tanganyika, Kenya, and Uganda stemmed from the native plants of Yucatan. At one time the major world-production of hard fibers was concentrated in this Mexican peninsula. The growth of the industry in British, Dutch, and German African colonies relegated Mexican production to a less important position. Over eighty per cent of her production, however, is used in the United States.

Henequen is produced on a plantation basis utilizing the poor soil of Yucatan. The characteristics of the plant are such as to permit fairly healthy growth on relatively poor soil. It is conceivable that enrichment of the soil would both increase the yield of fiber and perhaps improve its characteristics. Recommended expansion of technical studies in this field could lead to developments that would improve the competitive status of this fiber.

The methods of separating the fiber from the leaf have hardly been improved since the development of a decorticating machine made the large-scale production of the fiber possible. A new machine is now in process of development, but its operation in fiber production has not been tested. The new principle of defibration involved could lead to a much improved product. The henequen fiber is a long stiff fiber whose characteristics make it particularly useful in the manufacture of binder twine. As rope or sackcloth its stiffness and weight prohibit its successful competition with such other fibers as manila hemp or jute. It has been reported that the Germans successfully split the fiber and produced a soft flexible fiber comparable to that of linen. In the absence of details of the methods employed, research work to accomplish this effect and expand the field of application of henequen is justified. Waste products of the defibration process accumulate in large quantities. On the assumption that these materials may contain useful products, research work is being conducted in the Laboratorio Analytico de Henequeneros de Yucatan.[1]

The production of other hard fibers in Mexico results from the individual exploitation of the native vegetation. Lechuguilla, palma and zacaton are harvested and cleaned by hand. The first two involve the scraping of the pulp from the fiber by hand operations in which the leaf is drawn between a crude knife and a block of wood. After drying in the sun the fiber is ready for processing. All of the pal-

[1] Personnel from the Armour Research Foundation is conducting these studies in Merida, Yucatan.

ma and part of the lechuguilla is utilized in the manufacture of bags which are somewhat inferior to those made of jute. The better grades of lechuguilla are manufactured into bristles for brushes. Some are treated to resemble horse hair.

Zacaton is a plant root. The harvested fibers are bleached and manufactured into scrubbing brushes and similar articles. The greatest outlet for these has been Europe. The consumption in the United States has been relatively low.

Maguey fiber is obtained from the large leaf of the maguey plant usually cultivated for the manufacture of pulque. The thick pulp coating around the fibers has made present methods of mechanical defibration impractical. The fibers, therefore, must be obtained by scraping the pulp from them by hand. This method of operation seriously limits quantity production. Mechanical processes of separating the fibers would result in a much increased production of all of these fibers. Frequently, machines have been developed to accomplish the defibration, but as yet none have been sufficiently successful to be of great use.

Other fiber plants are growing wild in Mexico and are decorticated for their fibers by natives of the areas in which they are abundant. Some of these fibers have characteristics superior to any of those now in commercial production. If a mechanical process of defibration were developed one fiber in particular, pita de oaxaca, could seriously affect the hard fiber market.

Hides And Leathers

This industry is a picture of contrasts. Tanning factories having modern equipment and modern technics exist almost side by side with plants employing ancient methods. Several modern shoe factories may be found next door to a small home operation in which the leather is sewed and nailed together entirely by hand. Various degrees between these extremes are existent. The quality of leather and shoes produced is just as variable as the factories. A fair grade of sole leather is manufactured in Mexico but the upper leather is, for the most part, inferior to imported leather. This is one industry in which the presence of technically trained personnel in the plant greatly influences the quality of its products.

There is considerable room for improvement within the tanning industry. This improvement, however, must begin in the field. Tick bites, thorn and wire scratches, and butcher cuts seriously influence the characteristics of the leather. Branding practices frequently render a major part of the hide useless. Many of these faults could be overcome by application of recent developments in the field of insecticides and more interest on the part of the cattleman and the butcher in the ultimate use of the hide.

The tanning operations themselves call for increased application of scientific knowledge and better selection of tanning methods and materials. Modern tanning equipment would also be of value. A much better procedure of caring for hides after flaying would relieve defects arising from putrefactive changes in the skin.

The dominant native tanning material is obtained from the cascalote bean. This material is now being extracted at the tannery and the unstable extract used in the tanning vats. In some instances the ground or unground beans are added directly to the vats or drums. A method of extracting and drying the tannin[1] has now been developed to permit the tanner to purchase the tannin directly and to add definite quantities of the extract to his vats.

Mexico imports a number of materials, used in the tanning operation, for which she has adequate undeveloped supplies within her borders. For some of these, the development would be relatively simple; for others, however, an extensive research and development program would be necessary. Studies of the available oils are being carried out at the Institute of Chemistry of the National University of Mexico.[2]

[1] This process was developed by Armour Research Foundation sponsored by the Bank of Mexico. Either the liquid or solid extract can be produced.

[2] Technical and directional assistance has been provided by Armour Research Foundation.

Forest Products

The forest area of Mexico is given as approximately fourteen and one-half per cent of the area of the Republic. These forests vary from the conifer forests of the upper plateaus and mountains to the tropical forests of the humid and sub-humid regions of the southern and coastal areas of the country.

Lumber, chicle, essential oils, paper, naval stores, dyes and candelilla wax are some of the industrial products of the forests. By far the largest of these is lumber. The conifer forests have been fairly well explored and laws regulating cutting are controlling the rate of utilization of these forests.

The tropical and semitropical forests, on the other hand, contain woods of unknown types and quantities whose systematic exploitation could be a valuable source of income to the nation. Studies of the characteristics of these woods are in order, to avoid the unnecessary overcutting of Mexico's hardwood forests. The common practice of logging in tropical forests is somewhat different from that in conifer forests. Here the forest population is not predominantly a single type of tree, but a heterogeneous mixture of a great many varieties with the desired wood spotted only here and there in the entanglement. The operator selects the trees he desires and leaves the remainder, not injured or destroyed by the operations, standing. With a more complete knowledge of the characteristics of the remaining trees it may be possible to enlarge the operations and supply other materials to industry. Some progress has been made in the analysis of Mexican forests, but many years of work remain to be done.

Although the country is a producer of tropical hardwoods, the major portion of this lumber is exported for fabrication into finished goods. Expansion of this phase of the industry would increase Mexico's income from this resource.

Considerable care is now taken in the production of chicle to maintain a continued supply although much destruction of the forests was experienced in the early days of the industry.

It is important to mention the exploitation of guayule as a source of rubber during the war. Basing its activities on the wild growth of this shrub, several plants were operated to help produce the needed rubber. The operation of these plants during peace-time on the same basis is not considered an economical practice.

Technical Personnel

The supply of technical personnel in Mexican industry relative to the needs is low, but relative to the demand it is high. The slow rate at which industry is realizing the need for technologists has affected the educational system. The University has produced some of the best theoretical men in the world, but at the expense of practical industrial technologists. The scientifically trained man, unable to find reception for his training in industry, turns to the theoretical aspects of his subject. Developments of this type are essential to the progress of science and play an important role in uncovering fundamental concepts in the sciences, but they do not contribute greatly to the industrialization of a country. The present trend in education, however, has a strong leaning towards technological training as exemplified by the technological institutions of the country.

See A.R.F. on page 58

The Professional Man's Education For Citizenship

By JOHN DAY LARKIN

The industrial revolution has finally overtaken higher education in America. Some educators seem to deplore this, but it is a fact to be reckoned with. The whole academic fraternity has been undergoing a deal of self-analysis during recent years if we may judge by the volumes that have been published in defense of liberal education, the committee studies and reports on post-war plans at various universities, and the numerous public addresses of leaders in the educational field. Despite all this soul-searching on the part of the practitioners in the field of higher education, there seems to be less and less agreement on methods, aims and ends. In so far as generalization is possible, the most controversial aspect of all this is the problem of general education versus vocational and professional training at the regular college level.

This is not new, of course. But the divergence seems to have become more pronounced. Should education be general? Should we give young people a thorough grounding in the classics (i.e. the Great Books) or should we train them for a vocation or a profession purely in terms of present-day problems? The Great Books exponents maintain that by getting a thorough understanding of a number of the classics one has a broad foundation for leadership and that this should be obtained before one specializes. It is customary in the circles of the Great Books advocates to look with a patronizing air of suspicion—if not contempt—upon any professional training that is not grounded in four years of basic arts and science training and topped off with a superstructure of three years of graduate work in one of the bigger universities. As one who has gone through this kind of academic discipline, I am not the one to turn and sneer at such intellectual snobbery. However, I should like to make a few passing observations on the problems in our times.

Education for a democracy such as ours calls for training of varied types; and yet all of us are citizens and have a common responsibility as citizens. Ours is a scientific and technological society which because of its very complexity requires specialization. Our enormous productive process rests upon an army of trained experts, each fitted into his place like the cogs in a delicate machine. These experts would not be at hand if we had to put everybody through the same type of lengthy educational process. Modern science and technology can function and progress to its greatest efficiency and greatest good only through a widespread dissemination of educational opportunities. To make education and training widespread it must have variety. It must meet and sustain diverse ends. But in diversifying our training we must not narrow each field of specialization to such a degree as to lose sight of our common heritage or our common problems as citizens.

We have no quarrel with those who advocate the reading of Great Books, except in the matter of their insistence that those immediately out of high school be given this heavy dose of antique learning as a prerequisite to any kind of professional training. There is as much danger in thinking that the reading of a number of masterpieces in the humanistic fields of philosophy and literature (or even of past scientific masterpieces) is the whole of a liberal education as there is in going to the opposite extreme. It has been said that, "Education is designed to render men at once disciplined and free, disciplined to understand the nature of the world and the society of which they are a part, free by their competence and discrimination and range of feeling and thought to make intelligent choices."

For this there is no question that the masterpieces of literature are great resources. They embody in the accents of genius the distinct voices in which the human spirit has spoken at various periods and in various contexts of history. *But these are not the only instruments of imagination and understanding. They are not liberating to the spirit of men in our time if they are approached as if they were a set of sacred and finished doctrines to be stressed as the final repositories of wisdom.* Nor should these great books be approached as though they were addressed to no generation in particular. The works of Plato and Aristotle were written by Athenians, written in the context of a great society and with that society as its audience. These writings are not always fully understood when taken out of their social context—apart from the arts and sciences of their day. The same may be said of the writings of Dante, St. Thomas, and a host of others. It is doubtful if even the above-average high school graduate of today can read such classics with the fullest possible comprehension or appreciation.

An active, flourishing and aggressive vocational and professional edu-

cation has developed in the United States. It is here to meet the needs of our society. And it is making a real contribution to the intellectual and cultural life of today. Some of the best teaching in this country has been in first-rate engineering schools. Many colleges and universities are realizing the necessity of providing professional curricula at the undergraduate level while at the same time continuing general education in the arts and sciences.

Since the professional and vocational schools have made such rapid progress in recent years (in the matter of preparing young people to fit into the scheme of things in our times) the traditional liberal arts college has been put on the defensive. Many young people, who do not expect to become teachers, find that they cannot afford the luxury of a full four-year liberal arts course before getting on with their special training for the type of thing they hope to do. Time is of the essence. Thus we have vocational schools, and we have professional training schools. in law, in engineering, in medicine and its allied fields, making a sincere effort to compress a background of general education plus professional training into a period of four or five years. The University of Chicago's plan of attempting to compress the substance of general education into two years instead of four, so that those who qualify may get on with their professional study, and those who do not qualify may get out early, is but a part of this general trend.

In some instances the vocational and technological schools have gone to the opposite extremes as compared with the older arts colleges. They have lost sight of fundamental education. They have carried their specialties to such extremes that while they might be said to be training centers, they could hardly be called institutions of higher learning. This has resulted in a tragic separation in our society between what we generally regard as liberal education—the genteel education originally intended for the leisure class —and the technical training designed for *ad hoc* experts, prepared to do the technical but complex jobs of a modern industrial and mechanical society. The results of this separation have been rather shocking, and undemocratic. Such narrow scientific training has produced a class of purely mechanical experts. And the so-called liberal arts training has often produced a group whose thinking is so embedded in the past and so lacking in a comprehension of the science, technology, and economy of our day that there is an impassable gulf between the two.

In short, the liberal arts training was designed for the patrician of another day. It was training for the leisure class at a time when there was an established social order that recognized a leisure class. Its most ardent exponents and supporters today are to be found within and on the fringe of our more conservative social groups whose thinking is embedded in what they fondly refer to as "the good old days." At the same time, the pressure of economic circumstance generally forces the children of the less affluent to seek short cuts to remunerative employment. The consequence of the latter is a very abbreviated trade training, or a vocational schooling of a more extended sort, depending upon the ambition and energy of the young person involved. At any rate, the presumption is sometimes held that this segment of our society is not expected to take part in community leadership and the full responsibilities of citizens. At best this set of circumstances is perpetuating a division in our education, in our social order, and in our thinking, which is neither wholesome nor democratic.

American education must find a way to bridge this gap. We cannot continue as a house divided. Our young people of all occupations are active citizens. That is to say, they take their places in their professional and civic organizations, in clubs, in religious groups, in political organizations, and in trade associations. And through these the culture of our day is being shaped and reshaped. The time when the affairs of state were left to the patrician is past. Today we know that our civic leaders spring from the ranks of organized labor, from business associations, and from every phase of our social and economic life. Leaders in these fields must possess the attributes of statemen. They sometimes have hundreds of thousands, or even millions of followers. And these followers vote not only in their respective organizations but also in public elections. Through these large blocks of voting citizens such organizational leaders wield the power that was once the power of kings. It is the sovereign power, the power of freedom or slavery, the power of good or evil, the power of peace or war. Thus, when we are educating tradesmen we are educating citizens. When we educate citizens, of whatever walk in life, we are educating potential counsellors of state, if not the very statesmen themselves.

He is a stupid fellow today who does not recognize that every act of government — whether legislative. executive or judicial—has the effect of diverting funds from the pockets of one individual or group of individuals to the pockets of another individual or group. Knowing this we are not content to leave all matters of state to the privileged few, as was the practice a century and a half ago. Thus it behooves us as citizens to become familiar not only with the tools of our trade but also with the socio-economic and political factors of our world.

There has been much criticism in recent months of the selfishness of special interest groups, groups which have put forth pressure in Washington. and elsewhere, to have the instruments of government divert more of this country's worldly goods into their hands. But this is not new. The practice is as old as government itself. Each age and each generation faces the problem in a different form. Once the lords and masters wielded the power, exploited the weak and had the recalcitrant punished. They enjoyed the leisure. They controlled the purse strings. They had the power largely to determine matters of public policy. Today these distinguished gentlemen have been superseded in affairs of state by collective groups—by the "farm bloc", by the manufacturers associations, by veterans organizations, by powerful labor

See PROFESSIONAL on page 54

Incentives To Production

By HENRY P. DUTTON

Interest in incentive plans of wage payment seems to be perennial; papers were written on wages in the eighties and have continued ever since to occupy the attention of the engineering societies. Fortunes have been made by men with incentive systems to sell; apparently long experience in running a factory does not lead to confidence in one's ability to deal with the problem.

In spite of a half-century of study and attention, there never was a time, perhaps, during this period when we seemed farther from a satisfactory solution, or at least, when there was so little general response to increased pay in increased output. Part of this unrest and dissatisfaction with the existing scheme of things, and unwillingness to fit into that scheme, is of course the disillusion which always follows a great war. During that war, we reassured ourselves by saying that we were fighting for a better world, and we find ourselves with the same old world, as full as ever of problems and limitations. But labor unrest did not start with the World War, first or second.

It is difficult to conceive of a world this side of Heaven in which there would be no wage disputes. No principle for the division of the fruits of labor can be laid down which will satisfy everybody; even the communists had to abandon their slogan, "to each according to his need, from each according to his powers," in favor of a piece rate or similar system.

Chester Barnard in *The Function of the Executive* points out that in any cooperative human undertaking, whether a business, a government, or a church, the rewards which the executive can bestow on the workers are limited, and must compete for the allegiance of the worker with the incentives offered by other institutions. The executive, then, is constantly faced with the problem of using every possible incentive offered by the business —money, prestige, praise, interest in the job, public recognition, as well as such negative incentives as the fear of punishment, to induce cooperation. Since the productivity of an enterprise is limited, he must, in general, if the returns are to balance the outgo, disburse these awards with a calculated care. He may appear to be generous in his pay scale, but while the generosity may spring from an impulse to reward his companions in the venture, one is likely to find that it also pays dividends, for in general, low cost per unit of output is likely to be associated with high daily earnings.

The writer of this article has no simple proposal for curing wage disputes and failures of incentive, for these difficulties are inherent in the nature of man, whose desires are limitless in a limited world. But the writer is convinced that we often fail to get the most good from the wages we do pay.

One of the commonest troubles is the attempt to substitute a formula for a sympathetic attempt to understand the other man's point of view and the things that are important to him. It is relatively simple to time-study a job and set a piece rate, and it seems as though, when a man's pay depends on his own efforts, he should have every incentive to produce. It looks like a good solution and many an employer still cannot understand what is wrong with it.

In the early part of the century, when we were just beginning to appreciate the wonders of chemistry, scientists figured out the carbohydrates, fats and proteins necessary to support the activities of the body; a diet satisfying these requirements was an adequate diet according to the standards of that day. That such a diet could result in low vitality and resistance to disease and in lowered energy was known, but not understood until further researches led to the discovery of vitamins and other substances whose presence, even though only in extremely small amounts, was necessary to health. Perhaps it is time to give attention to the "vitamins" in working relations.

Before we do, let us re-examine the old wage formulas. The oldest of them is day rate, a sort of commutation of the ancient reciprocal obligations of sovereign or master and subject, serf, or yeoman. The worker undertakes to perform a certain service in return for a fixed wage. In itself, the day wage offers stimulus to production only because if one does less than the employer expects, one will lose his job. There is no special automatic recognition of performance beyond this minimum, although in the hands of a discriminating boss who uses promotion and praise or just criticism where they are deserved, workers under day rate may have a fairly effective stimulus to productivity.

Professors generally work on a time rate system, and while the writer would be the last to assert that all professors are high producers, some of them and of the scientific workers who commonly are similarly paid, reach at

times a very high productivity. In general it may be said that when a man's work is interesting and constitutes in itself a stimulus to productivity, the financial relationship may usually be adequately taken care of by a fixed wage, commensurate with the customary income of the class, equal to what others would be willing to pay the same individual or type of worker, but not directly related to productivity. Productivity is further rewarded by periodical promotions as deserved, by professional recognition and by various non-financial compensations. When a man's work is interesting enough, he works best when he can forget extraneous financial worries and concentrate on the thing that interests him.

A majority of executives and professional and sub-professional workers are paid on a time basis. It is very questionable practice, for example, to pay time study men on the basis of savings made. First, doing so puts them under temptation to take short-cuts which later lead to trouble; second, the work is so interesting to a good time study man that you don't need to pay him extra for doing his best.

The enterpriser, the man who starts the business and takes the risks in hope of profits, is of course on a sort of incentive system, maybe a piece rate. But to him, profits (nice in themselves, of course), are in some sense a measure of a dream come true—power, security, prestige, ammunition for further developments, or the reward of the successful trader. These men picture others as motivated by the same drives that animate them.

But the average worker does not dream the dreams of the entrepreneur. He knows, of course, that he has a chance, if he was born in the United States, of one day becoming its president. But he does not fit his life plan, very often, around the hope of being president. He wants to earn as much as he can, of course, but, in most cases he no more dreams of establishing his own business and becoming rich thereby, than he does of becoming president. What he wants is as secure a job and income as he can get, the ability to live as well as his neighbors, the feeling that he is "adjusted" and secure and reasonably recognized in his community of family, neighbors, fellow-workers, and other associates.

Piece rate, perhaps the second oldest plan of wage payment, can meet these basic needs as well as day rate if it provides equal security and pay. Furthermore, piece rate is usually preferred to day rate by workers when it has their confidence. But piece rate, and for that matter, almost any incentive system, suffers from several weaknesses that may cause serious trouble in inexpert hands.

The basic principle of piece rate is that one takes the prevailing rate of pay for an occupation, $1.00 per hour or whatever it may be, and determines the output of the normal worker on the particular job. Thus, if the rate is $1.00 and the normal output is 100 pieces per hour, then the piece rate would be, let us say, one cent per unit.

All this is clear enough. The trouble is with the definition of "normal output". In a day rate shop, high output is sometimes secured by urging, nagging and close supervision, good or bad. But often the management, and for that matter perhaps the workers themselves, have no idea how much more could be done, without undue fatigue, were there a real incentive to turn out the work. So when piece rates are put in, it very soon becomes clear to management that they guessed very wrong on the rates. In one shop, rates were set so that the men would have to turn out twenty-five per cent more work to earn the same money, on the assumption that there would be some increase of output. The men struck, and were replaced by unskilled novices, who very shortly presented management with a new problem; not knowing how little one did for a day's work, they were earning four times the previous wage of the skilled man.

Here is the basic problem of incentives, to determine what is a "fair day's work". Of course, when management found that it could get five times the previous production they cut the rate. Why should they pay $10 per day when (at that time) they could have gotten the work done for $2.50 by firing the present crew and starting another at the lower rates? It was more sensible to cut the rate.

This sort of thing has happened innumerable times; it has become part of the background of belief of the laboring man. If you have to play a guessing game with management, it is better not to show all your cards. Men soon know about what maximum earnings the management will tolerate, and regulate their pace accordingly.

In every group of workers there are likely to be one or more who do not see why they should regulate their earnings to fit the accepted shop pace. They need the money or are ambitious. When management reviews the earnings of the crew, the wages of these men give a very clear indication of what others could do if they were minded. Similarly, when a time study is being made, many workers are tempted to show how good they are; unconsciously, they turn out a better than normal output. As a result, they and their fellow-workers eventually find to their sorrow that the only result of this diligence is that they are expected to keep it up all the time.

Naturally, the need to prevent a bottomless cutting of rates is to get together, agree on how much shall be done, and take measures to see that no one endangers the safety of all.

In every group there are some who work exceptionally fast, as well as some slow ones. It is a pity that all must be held to the pace of the average or a little below, but self-protection comes first.

Naturally, there have been attempts to break this vicious circle. Frederick Taylor, and many since his time, have reasoned that for a given task there is a normal time of performance. Gilbreth's therbligs or motion elements have been timed; two people performing the motion element "transport loaded" in the same way should take about the same time. After all, the arm, for example, is a mechanical member; if a normal or average force is applied to it, it will accelerate and travel a given distance in a given time.

If one were to break a task into elements and time the elements, using tables of normal times, it should be possible to predict the time required for the operation, without the necessity of timing it, except as an overall check.

There is promise in this approach. but it also presents many difficulties.

Only in extensive operations, often repeated. would the expense of a thorough analysis justify itself. For less costly studies, the estimator would be driven to guesswork and approximations, in which the allowed times for certain elements would at best be "bench marks" by which to gauge, by comparison of the times on a few known elements, the accuracy of other parts of the study.

Such standard times need also the prestige of some recognized national body, supported by labor as well as management, if they are to have the confidence which will remove from the worker's mind the extreme reserve with which the machinations of management, and of those management engineers who sometimes out Herod Herod, are often regarded.

This approach also tends to neglect another angle of rate making. It would be nice if bargaining could be concentrated on the hourly rate, leaving the method and the time to be established scientifically by experts in whom both sides had confidence. But labor does not think, nor feel, that way. For one thing, the idea of the unvarying, scientifically determined method and rate of performance, charming though it is to the production man, somehow fails to arouse enthusiasm in the breasts of workers.

In the first place, the rate of production is regarded as just as much a matter for bargaining as the rate of hourly pay. When times are good and jobs easy to get, nearly everybody tends to give a little less for the money. There is no good, logical, economic reason why one should do less work when there is a frantic demand for his product. But the worker has had to swallow things he did not like a good many times in the average lifetime; here is one moment when he can tell others where to head in. Human, reprehensible, but he enjoys his moment of power. When demand slacks off, for a time everybody will work as slowly as he dares, putting off the evil day of the layoff. and when it is plain that somebody's layoff is inevitable, everyone will tend to work a little harder so that it will not be he.

Also, the trade union has been an apt pupil of our earlier monopolists. Many unions devote a good deal of high-grade talent to devising ways of delivering as little as possible in the way of output, on the theory that scarcity raises prices. Among all these cross currents, the idea of the scientifically set task needs much more support by public opinion, before it can become a realistic basis of industrial negotiations.

Finally, this method of task setting is after all applicable only to a rather small fraction of the total production. Obviously it does not apply to brain work, nor to selling, nor to skilled nonrepetitive work like display composing of type, toolmaking, and to many areas only semi-standardized like hand-poured foundry casting. The study of this approach is useful, for it may shed light on the difficult problem of taking the guess-work and the need for defense against over-covetous guessing out of rate setting. But it is one aspect only, and perhaps not the most important, of the problems of securing effective incentives to production.

So far, the most apparent result of a half century of "scientific" rate setting has been to fortify and harden labor's resolution to have none of it. Union after union is using what economic leverage it has to endeavor to force standardization and uniformity in wages. If many unions had their way, pay in a skill classification would be governed wholly by seniority; increases (and layoffs) would be automatic and quite unrelated to output. save for the enforcement of union-approved shop rules. Some unions are working to make promotion equally automatic. and independent of productivity. A far cry from the engineer's ideal of maximum productivity, consistent with the long-time health and welfare of the individual!

What, if anything. can be done about it?

I have in this discussion omitted the usual description of the numerous incentive systems, partly because they can be studied in any one of dozens of books of reference, but partly because of a feeling that what we need is not more, but fewer, varieties of incentive systems. Of the various bonus systems. which pay for savings above a standard or allowed time, a few, such as the Halsey plan, particularly with 100 per cent bonus, are useful, but they offer little significant variation from piece rate, which is usually the best system. where the work is standardized to a degree permitting accurate and low-unit-cost rate setting.

One thing those responsible for wage policies in today's world are going to have to do is to recognize that it takes two to make a bargain. Whether the employer likes it or not, his plan must square with the ideas and beliefs of his employees, which means those of labor generally. In the union shop. business agents (who also have Barnard's incentive problem) will be quick to make capital of proposals which run counter to union policies. In the non-union shop, workers are not as quick to express themselves or to oppose the employer's proposals. but they nevertheless find ways to sabotage an unwanted proposal, and there is always the union to turn to.

Quite apart from the strategy of the situation, why should an employer or his representative, the time-study man. fear to discuss a proposed standard time with the man concerned? If there is going to be an objection, it is better to get it out of the way before it causes trouble. Many labor troubles start with an accumulation of small grievances about rate inequalities, too small individually to make a fight about, but enough in the aggregate. It is better to have up a lightning rod of free discussion, to conduct off these grievances before they reach a dangerous potential.

Finally, ought we not to re-examine not only the financial incentive but all the incentives to factory work? We may find we have been feeding a diet adequate financially, but resulting in spiritual starvation — lacking, somehow, in those vitamins essential if a man is to find his daily task satisfying. I realize that this, coming from an engineer, may sound a bit lyrical, but the issues involved are of tremendous national importance.

See INCENTIVES on page 42

Safety

TRAINING AND TESTING DRIVERS

By Robert C. Peterson

During the past year the Institute has conducted regular day and evening classes in industrial safety. With the organization of the new Department of Fire Protection and Safety Engineering, succeeding the long-established Department of Fire Protection Engineering, the instruction in industrial safety has been extended to cover the study of causes and prevention of highway accidents involving motor cars. Besides material directly relating to driving, the program involves treatment of such allied engineering problems as vehicle design, proper methods of loading, acceleration and deceleration, and impact.

The work will be carried on in the classroom, and by tests of personal characteristics and of driving habits and skill in the test room and on the street. In addition to the students who enroll in the course as a required or elective subject, other students, as well as members of the Institute faculty and other employees may have opportunity to take the tests.

Reaction Time: Measuring of time required to move the foot from accelerator to brake when light changes to red.

An immediate object of the program is to provide students with such understanding of highway safety problems as will help them individually to avoid being the victims of accidents. Beyond this, it is to be expected that the knowledge and habits of safe procedure that students acquire may "leak" to their families and their other associates. Occasionally, if we are fortunate, some of our men may become enthusiastic enough to do really active missionary work and exert great influence in their industries, their homes, and their play. This indirect effect on drivers who have not themselves taken the course should help to dispel the false feeling of security, the thought that only the other fellow is likely to be in an accident, that is characteristic of most drivers.

From a somewhat different point of view, an object of the course is to help supply the rather considerable demand from industry for training of this kind for men who may later be

assigned to duty as traffic managers or in other executive capacities.

Procedures for the selection, testing, and training or re-training of operators of motor vehicles are especially important during the school years. Statistical surveys show that drivers under twenty have five times as many fatal accidents as the forty-five to fifty-one group. Seven out of ten of our young people drive cars during their last year in high school or within one year thereafter.

The program provides informational, background data leading to recognition and understanding of the problem. Demonstrations in the classroom and in the field are used to prove that reliable procedures are available to assist drivers in overcoming defects and correcting detrimental habits, as well as in the training of new drivers. As the student proceeds through the course, his general awareness of the problem crystallizes into a clear, factual appreciation that proper handling of a motor vehicle calls for good physical condition, alertness, accurate driving judgment, and a high degree of skill in the physical manipulation of a heavy, powerful mechanism capable of rapid motion.

In the classroom students become acquainted with the battery of tests of physical fitness, involving field of vision for motion, visual acuity, color vision, hearing, and reaction time. The latter involves the time required to move the foot from the accelerator to the brake pedal when a red light appears or an emergency develops. Time is given to discussion of practical application of sound theories of car operation and maintenance. Indoor demonstrations of the physical tests give the students familiarity with the mechanics and techniques of testing, and are intended to aid him in the interpretation and evaluation of the test data. Since it is assumed that some of the students may eventually be responsible for selecting or training drivers with various educational backgrounds, attention is given to the importance of literacy in relation to a driver's ability to keep himself informed about safe driving instructions and regulations.

The test of reaction time is particularly important because it indicates the driver's stopping distance at various speeds. A correction factor must be applied to the test data to make allowance for driving at night, with the possibility of coming suddenly upon an obstacle such as a stalled truck. The student learns not to overdrive his headlights. Stopping limits must be adjusted to a distance in which the operator has a complete, clear field of vision. Wet or otherwise slippery road surfaces, worn tires, the nature and volume of traffic, the presence or absence of traffic lanes, and other factors come into the problem of operating without accident. A driver's reaction time is not constant, but varies with his age, physical condition, and driving experience. It is desirable that rechecks be made at suitable intervals, and that the driver know his own characteristics in this regard. Of course reaction time is a key factor in the prevention of rear-end collisions.

Actual driving tests on the road are various and important, but they are not discussed here in detail. Procedures and equipment for this part of the program involve driving on a straight line, gaging space when steering in close quarters, stopping and starting smoothly, estimation of front and back line limits, turning around, and parking. They also include experimental demonstration of distance required in coming to a stop from various car speeds.

Most of us think of highway accidents in terms of the suffering and death of a shocking number of our people each year. Aside from this dramatic aspect there are economic phases to be considered. In commercial fleet operation a bad accident record is regarded as an indication of poor management. It means financial loss, interference with normal operations, perhaps difficulty in obtaining insurance. The owners of important fleets focus critical attention and decisive action on such items as preventive maintenance, driver training, accident prevention programs, special body designs, studies of loading and routing, etc. Although humanitarian motives are not ignored, this safety policy is justified on economic grounds. It has an important bearing on operating profits. Moreover, it has long been recognized that a commercial vehicle is a "billboard on wheels," and that it may produce unfavorable reactions in the minds of the consumer public.

Many organizations have done valuable work in improving the accident situation in modern motor vehicle practice. This work will continue, but it can not be fully effective until there is much greater feeling of individual responsibility. No person who is on our city streets or our country highways can properly ignore the safe procedures that will help to save him from injury and loss, and at the same time increase the safety and protect the property of others.

Collateral to the matter of proper design and safe operation of motor vehicles, there obviously are problems of highway design and maintenance, vehicle licensing, zoning requirements, speed regulation, and law enforcement which are important parts of the safety program, but which are not within the field of the present discussion.

While formal class work relating to safety in motor car operation has only recently been established at the Institute, the subject has been given careful attention by members of our faculty for many years. More than twenty years ago the ENGINEER published an article on automobile brakes, written by Professor Daniel F. Roesch; with other technical material which is still valid, he described equipment of his own design for the measurement of driver reaction time. Professor Sholto M. Spears was the author of an article on psychological problems involved in highway design and the design and location of traffic control signals. The late Professor John F. Mangold wrote two articles on problems in the mechanics of motor-car operation.

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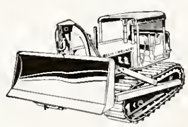

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FIRE—

(Continued from page 12)

nical progress giving him a silent servant which needs to be kept under constant control to keep its powers in leash. As the extent of our knowledge of electricity has increased the hazards which it introduces are gradually coming under control. The increased use of inspected equipment, continuing enforcement of the National Electric Code, and increased emphasis on the necessity of replacing worn equipment will eventually take electrical hazards out of the most serious class. Prior to the war, this improvement was taking place; however, the lack of replacement parts in the last five years has resulted in the breaking down of insulation which became dry and brittle with age and usage. The more widespread use of tamper-proof over-current protection in post-war construction will also help in this respect. Here is one of the lessons of our war time experience. We have always appreciated the dangers inherent in over-fusing or shorting out the fuses in branch circuits. During the war fuse-boxes were recognized as possible sabotage points and received careful inspection from all plant protection personnel. Many plants within my personal knowledge reported that their inspectors day after day were collecting pennies, nickels, and other gadgets designed to short out the fuses. These were not placed in the fuse receptacles by saboteurs or alien agents, but by well-meaning American citizens to whom that method of handling a troublesome circuit has become routine. Our only solution is tamper-proof fuses, whether they be the so-called type "S" fuse or other equally reliable equipment. The NFPA at its recent meeting voted to include the provision of this type of equipment as mandatory in the Electrical Code. It is now up to us in the safety profession to insist upon this type of equipment wherever possible.

Number four on my list of outstanding fire causes is the hazard created by stoves, furnaces, boilers, and pipes. Here is the original fire hazard which we have had with us since our forefathers first learned to make fire do their bidding. The problem presented is fairly simple; it is purely one of heat transfer. Extensive rsearch has shown that we have a margin of safety if woodwork is kept below 165°F. Where our trouble develops is that under normal operating conditions the average heat producing and utilizing does not require much clearance or insulation to keep adjacent woodwork below 165°F. However, many conditions may arise, such as overtaxing the device beyond its normal load, a burn-out of accumulated soot in the pipe, or long continuous operation of the device, any one of which will result in an unexpected temperature increase causing ignition of adjacent wood. An excellent example of this is the average vent from a commercial range. I have seen many installed where the exhaust vent passes through a combustible partition or roof with no clearance. The justification is always the same—this is merely for venting purposes and it does not get hot. Of course, eventually the inevitable occurs. The grease which has slowly accumulated in the pipe ignites and we have a burn-out. The pipe which we could always put our hand on is now red-hot and the adjoining woodwork begins to smoulder. The solution is obvious; all stoves, furnaces, boilers, and pipes, should be designed, and what is even more important, installed as if they were going to operate under the worst conditions possible and still not raise adjoining combustible material to more than 165°F.

Number five on this list of public enemies is spontaneous ignition or spontaneous combustion as it is more commonly called. This hazard produces an extremely high monetary loss from a relatively small number of fires because of the insidious manner in which it starts. We are all familiar with the nature of the phenomenon which starts generally as slow oxidation with the evolution of heat. As the temperature increases, the reaction speeds up until the ignition point of the material is reached. Research has provided us with a fairly definite classification of the tendency towards spontaneous heating for the most commonly used industrial materials; however, each new product encountered in industrial development must be carefully tested for this quality. Our best protection against this hazard lies in automatic detection of the temperature rise and automatic extinguishment as needed. We have the automatic equipment today required to control this stealthy hazard.

I have discussed five specific causes which have contributed heavily to the upward trend in fire loss in this country. There is one other condition I would like to call to your attention which has developed since the end of the war. During the emergency, large industrial plants employed plant-protection personnel in large numbers both in fire fighting and fire prevention activities. These men built up a wealth of experience and became adept in the performance of their duties. With the end of hostilities they were the first to go; they scattered to the four winds, and plants which were models of protection and prevention today reflect sorry spectacles of short sighted management. Millions of dollars in equipment are jeopardized to save a comparatively small amount in payroll. Those of us left in the picture have a superhuman job to perform. We must fight for automatic detection equipment where man power is reduced. The country cannot afford the needless loss of materials at this time.

In conclusion let me show you a picture of our problems as I see them. We are engaged in a race with our fellow engineers, electrical, mechanical, chemical, shall I say nuclear, and all other scientists who are striving to harness the forces of nature to provide a more abundant life for us. Each conquest of theirs, be it fire, water, or the atom, presents a threat which must be controlled lest it devour us. We must keep step with them, we must be ready at each new crossroad to erect the guide posts which will enable our fellow citizens to utilize to the fullest the achievements of science without destroying themselves.

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THE SCHOOLMASTER

Manners and Manner. Our young men who have returned to us from the war have both. When a large part of our student body were in ASTP or in the Navy V-12 group our civilian faculty members became used to being addressed as "Sir." Now our classrooms are filled beyond their normal capacity with students, most of whom were in uniform a few months ago: they retain much of the military courtesy which they acquired while their real work was the deadly, dangerous job which they did for us who remained at home. In our part of the country it was not formerly the custom to say "Sir." The matter is not of great importance.

Manner is something else. A teacher finds new satisfaction and feels especially great responsibilities when he faces these men with their calm confidence and their obvious intention of getting the most from the college years which have been postponed or interrupted for two, three, or four years, or even longer.

Not all of our students are veterans. There comes to mind a sophomore class of last spring. It was fairly evenly divided between boys only a little more than one year out of high school, and men who were older by about five years by the calendar. Their seniority was better expressed by saying that they were older by a war. Most of the students in both groups did excellent work and it was a pleasure to work with them. It is permissible for a veteran teacher to say that we can be proud of our young men. In addition to our formal entrance requirements and the careful work of our department of admissions, the knowledge that our program is severe screens out many who have not the necessary aptitude and industry. One of the principal assets of every good college of engineering is its reputation for maintaining rigorous standards.

(Continued on page 36)

(Continued from page 34)

College Finance. A man may *spend* four to seven years of his life in college; some one, the student or another, spends considerable amounts of money for his tuition, fees, and living costs. The venture requires the giving up of earnings that would otherwise be made. The return on the investment need not be discussed here in detail. Most of us in America consider that for ourselves and our children college training must be provided if it is at all possible, even though it calls for strict economy and careful contriving. We are not here concerned with theories of education, nor with praise or blame for our colleges. A college course is more than an investment. It is better to say that the word does not come near to being completely descriptive. Nevertheless, the money side is important.

Recent legislation has made college training available to many men and women at government expense. Before the war, registration in colleges was increasing more rapidly than the growth in population. With the exception of a very few schools, tuition fees collected from students have not been and are not now sufficient to maintain the schools. The difference may be made up from the public revenue, as in the state universities; it may come from the interest on endowments; it may be taken care of by gifts for designated uses or for general expenses, as distinguished from contributions to endowment.

Thomas Furlong in the *Chicago Sunday Tribune* of September 22, 1946 reports that the endowment funds of universities, charities, and scientific foundations are growing, by reason of the tax exemption of these institutions under the federal statutes. He points out that men in the high income tax brackets may make gifts advantageously during their lives to educational and charitable institutions, and that property bequeathed to such agencies at death is exempt from the federal estate tax that reaches a rate of seventy-five per cent on the largest estates. One need not be a college treasurer to know that returns on investments are much lower than they were formerly. But only elementary arithmetic is needed to show that a contribution of $30,000 annually is equivalent to an endowment of $1,000,000. Thus, a large number of American colleges are developing the "living endowment" system, which calls for annual contributions from alumni and other friends. The success of the plan depends upon efficient organization and publicity, and most of all upon the maintenance of standards and of performance that justify the recurrent requests for contributions. The loyalty and generosity of the graduates of the school are important, but cooperation must come also from others who are influenced by a sense of civic duty or from an appreciation of the value in their own affairs of a

(Continued on page 38)

(Continued from page 36)

continuing supply of men with suitable preparation.

The setting up of a procedure for annual contributions should not of course reduce the probability of single gifts for designated purposes or for general expense.

The question of scholarships suggests itself in any discussion of college finances. The award of a scholarship assists a deserving student, but it is not normally of money value to the school, for reasons that have been already mentioned. A scholarship should provide an amount which is at least equal to the total cost per student, and therefore considerably greater than the standard tuition and fees. Scholarships may be established for philanthropic reasons. On the other hand, they may be set up by business organizations from motives of hard common sense and prudent foresight. Among the graduates of the Institute are several hundred who have held scholarships of this latter character, and the sponsors of the plan after nearly twenty-five years of experience with it are planning its continuance and expansion.

Two other approaches to the problem of college finance are possible. First, tuition charges might be raised so that they will cover operating costs and all other expenses, including maintenance, replacements, and perhaps expansion. Obviously, the effect would be to make a college course a luxury which would be available only to the sons and daughters of families on a high economic level. That we do not want. In the second place, college education, like elementary and secondary education, might be at public expense. To a degree, this is already the practice in the state universities. It could be extended, and the support might be from federal funds. Perhaps that is desirable, but the thought brings up uneasy remembrance that he who pays the piper may call the tune.

The Schoolmaster is not an administrative officer of the Institute, and not a member of the teaching faculty. But after many years as student and teacher in colleges which are not parts of a public educational system and which have no large endowments it appears to him that our independent American colleges will continue to maintain their prestige. In each case, the present and the future success will be a function of the energy, intelligence, and foresight of the personnel, administrative and educational, and of the far-sighted generosity of men and businesses in the communities that are served.

CONTRIBUTORS

(Continued from page 4)

Award in 1941, and the Pi Tau Sigma Gold Medal Award in 1942. He has held a fellowship awarded by the National Academy of Sciences and has visited England and Germany on missions relating to jet-propulsion aircraft and to enemy technical development. Dr. Rettaliata's article, "Linear Relationships in Gas Turbines" is an address delivered at the Midwest Power Conference, April 4, 1946.

INCENTIVES

(Continued from page 26)

We need somehow to make the individual count again, as he did in the days of the small one-man-operated business. Life was harder, and there were bad bosses, but at least a man was an individual and not a cog in a machine.

A good many radical experiments have been tried, and have mostly failed, in the effort to achieve that aim. I do not think we need abandon the machine nor mass production to do it.

We can do a good deal simply by making the most of *all* the incentives offered by the job — discriminating recognition of good performance, fairness in promotion, simple friendliness and an appropriate interest in the employee and his affairs, more freedom and less regimentation in small details and regulations. It is so easy to get into a rut in thinking, to be satisfied with a routine time study. It is so much easier to talk than to listen. One reason I like thorough-going motion study is that it gets the two sides together on a common problem, attacked with sufficient thoroughness so that both sides know each other and the facts. Certainly the man who lays out work and tasks for other people should do his utmost to make the task interesting, a challenge to and an outlet for the powers of the worker. On those unvarying routine tasks which present the least natural stimulus, more use may be made of simple social stimuli such as music, rest periods, and the like.

The long dispute over wages and tasks has driven the management and workers of America into a stalemate which is a serious threat to our national welfare. Management can do its part to compose these dangerous differences, this suicidal opposition to productivity, by re-examining its own premises and beliefs. Perhaps unrestrained individual competition between workers is getting to be more or less an anachronism in these days of conveyorized, paced production. In the last analysis, the basis for pay is going to be day rate, the going market rate, rather than any specified piece rate. Perhaps we might get farther in the ticklish task of translating the market wage into a piece rate (which is, after all, the logical way to pay for repetitive performance) if we were to rely a little more on the good faith of the worker and let him help determine what is a fair performance, using the trained specialist as a teacher more than as counsel for the prosecution.

LITHOGRAPHY —

(Continued from page 10)

production plants generally were too small for individual action since they were serving commercial rather than magazine or newspaper customers. Their volume of supplies was also still too small for suppliers' research except as a by-product of supplies for all the graphic arts. The lithographers knew that they wanted their own inks, papers, and other supplies especially suited to the chemical nature of the process. And they felt that steps could be taken to force fundamental improvements in the process, techniques, and materials toward lower costs, less hand-work, greater speed in production, and greater standardization.

After three years of discussion and planning they launched a cooperative research program with a $750,000 endowment and a research laboratory of their own. And they tied to it an educational program designed to collect and publish known practices and techniques and supplement these with education on the new developments from research as they came along. The resulting institution is known as the Lithographic Technical Foundation: concerned with cooperative research, education, information, and technical plant services only: not with trade relations, labor relations, tariffs, or legislation—the activities that belong in associations.

Probably no industry ever received so much direct benefit from the small research expenditure that was provided by income from endowment, supplemented sparingly and only occasionally by special gifts.

It is more than coincidence that since the establishment of the Foundation the industry grew from 300 plants doing $75,000,000 worth of business a year, to 2,100 plants doing $300,000,000 worth of business a year, with more than a 300 per cent increase in skilled craft and front-office personnel.

The industry survived the 1929 crash and 12 years of depression better than did the Foundation endowments. And strangely enough, in an industry devoted to the development of an important channel of communication of ideas and information to the public, a not too good job was done on its own internal informational services. The result was lack of sufficient knowledge on the part of the new and even of the old plants of the excellent research and educational work being done and which could be done. This resulted in static rather than increased support.

Fine, high-speed offset lithographic presses came along in 1928 with accelerated developments in photomechanical methods and equipment such as the step-and-repeat or photocomposing machine. By 1935 the industry had doubled in dollar volume right through a depression, yet it would not or did not increase its research and educational activities.

By 1940 to 1941, the industry was quite heavily drafted for map and other war reproduction work, and its skilled manpower heavily drawn upon for field service, some in total units. By that time also, small and medium sized offset equipment, first developed in the early thirties, was being recognized and smaller plants were growing up rapidly.

By 1943, every lithographic plant was filled to capacity and feeling acutely the need for the standardization of techniques, materials, and supplies and, above all, the need for increased skill of its craftsmen.

The voices of the research and educational men who had been preaching these philosophies and demonstrating their value, too often in vain, began to be heard. A demand arose among the original 400 members and contributors to the Foundation's endowment who had not reached in their pockets to any extent since the original endowment was set up in 1924. (As usual in many industry cooperatives, a few had increased their support, but all too few.) They wanted the pace of research stepped up, the scope widened and the benefits spread to meet the needs and opportunities of the industry.

Reorganization was effected early in 1944 by increasing the Board of Directors from twelve to eighteen, limiting their term of office to three years, and ruling out their re-election. New officers and directors were elected and a full-time Executive Director hired to develop research and education programs more nearly fitting the real needs, size, and importance of the industry. A program was projected for increasing the endowment. More important was the decision to become active in obtaining annual membership support to provide increased annual operating funds.

In eighteen months the shrunken endowment of $452,000 was increased to $1,000,000 and annual dues of $75,000 a year obtained. This year the budget of $150,000 based upon anticipated income and covering all activities represents the equivalent of income from a $5,000,000 endowment and is approximately six times the average for the first twenty years. Research and educational committees representing the best brains of the industry have been studying the real needs of the industry in true relation to its opportunities, growth and development. Their current recommendation to the industry is for a budget of around $250,000, a little under one-tenth of one per cent of that part of lithographic gross sales which would be affected by research and educational activities. This is conservatively in line with the investment in cooperative research of those industries which have it. The goal is to make educational activities self-supporting by supplying the necessary shop manuals, texts, training courses, research bulletins, technical papers (currently 106 titles) at cost to members and non-members. Lithographers themselves pay 60 per cent of the cost of the programs. Because of the nature of their linked chemical process, the problems of the suppliers and lithographers being inseparable, suppliers pay 40 per cent of the bill.

Methods of fund raising employed in the first two years of reorganization since 1944 were various and the programs comprehensive. The emphasis has been on the "pass the hat" technique, explaining aims and objectives and projected plans and programs on a general basis. Full recognition was and is given to the quality of the splendid past accomplishments as justifica-

(Continued on page 46)

(Continued from page 44)

tion for increased research and educational activities.

During the reorganization and early refunding period from 1944 to 1946, a heavy schedule of writing for producing texts, manuals and courses to prepare for G.I. and civilian training was carried out.

Along with this outstanding accomplishment came the provision of modern, new research facilities and increased manpower through contract association with Armour Research Foundation. The laboratories were moved to Glessner House at Chicago. At the same time, new but lower cost administrative and educational headquarters were provided in New York.

These achievements provided interim news while research and educational accomplishments began to develop under the reorganization program with increased funds. They also provided dignified, identifying focus points in accordance with the best practice and experience of successful, industrial, cooperative institutions.

Currently, the best methods of obtaining increased support and the goal of $250,000 to $300,000 are:

1 To tell the industry the real research needs, specifically what the money is needed for, based on surveys and research committee analyses.
2 To point out the need for long-term planning and fundamental research to diminish somewhat the pressure for the advanced trouble shooting type of research.
3 To urge that investment in research be considered to be a premium on insurance for the future.
4 To emphasize benefits and accomplishments (of which there are plenty) past, present, and in the future.
5 To publish financial statements, budgets, lists of members by classification, and in general to take members and prospective members into the complete confidence of the Foundation management.

Of interest perhaps is the fact that funds raised to date in the reorganization have cost less than five per cent. This low cost is due to activities by officers, directors, and staff. Cooperation of trade press and supplier members has been exceptional. Currently operating is a proven success of the war. the War Advertising Council formula of sponsored trade press and house organ advertising of high institutional value to donors. The tax situation has been favorable although the war and later war appeals for funds have had priority.

Whether the appropriation goals that will produce the greatest benefit to the industry and the greatest efficiency of operation can be reached depends to a large extent on the penetration that can be achieved for the outstanding story of needs, benefits, and accomplishments.

The accomplishments, needs and benefits being emphasized are these:

(Continued on page 48)

Harnessing the Power of Niagara

For thousands of years, water had roared over Niagara Falls at the rate of about *200,000 cubic feet per second* —representing enough power to supply the annual requirements of *24,000,000 average homes*. This enormous power continued to go to waste until...

In the late 1880's, a group of world-famous engineers began to study the problem of harnessing the vast power of Niagara Falls.

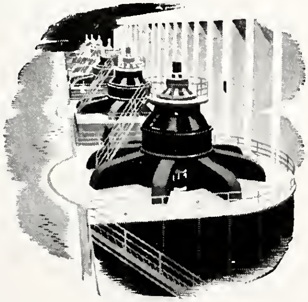
A bitter controversy raged for years as to whether *alternating* or *direct* current should be used. George Westinghouse, the world's greatest authority on alternating current, vigorously supported the *a-c system*.

Then, at the Chicago World's Fair in 1893, Westinghouse demonstrated the unqualified supremacy of the *polyphase system* for the *generation* and *transmission* of alternating current electricity.

In October of that year George Westinghouse won his famous "battle of the currents"—and received the contract for three 5,000-horsepower polyphase generators to be installed at Niagara Falls.

These world's largest a-c generators had to be engineered from the ground up. But within two years, the three mammoth units were placed in operation. And a year later electric power was supplying the needs of Buffalo, N. Y.... *20 miles away!*

It was a major victory for mankind as well as for George Westinghouse—for it *set the pace for power development all over the world.*



Westinghouse

PLANTS IN 25 CITIES · OFFICES EVERYWHERE

TODAY—The Westinghouse Electric Corporation supplies much of the world's needs for the generation, transmission and utilization of electric power. For instance, throughout the world there are Westinghouse water-wheel generators with a total capacity of more than 12,000,000 kva. In addition, steam and engine-driven generators, with a combined capacity of *many more million kva,* proudly bear the Westinghouse name plate.

Tune in: TED MALONE, Monday, Wednesday, Friday, 11:45 am, EST, American Network.

(Continued from page 16)

I. Past Benefits, partially summarized:

1 Valuable contributions toward the goals of better offset papers and paper conditioning methods, especially the prehumidified or preconditioned papers of today.

2 Better press-blankets and rollers.

3 More reliable albumin pressplates, better understanding of deep-etch plate methods, and a new deep-etch method designed to meet the war-time alcohol shortage.

4 Standardized procedures: pH control of coating solutions and fountain etch: hydrometer control of dichromate: the effect of temperature and relative humidity in plate making.

5 The trend toward standardization of chemicals and development of new chemicals (which any shop may use and any manufacturer make and sell).

6 Standardization of lithographic inks.

7 Improvements in dot-etching.

II. Research Committee's recommended projects for 1947:

1 Tone reproduction in half-tone photography: light sources.

2 Standardization of graining procedure.

3 Studies in desensitization.

4 Wetability studies on metals.

5 Effect of relative humidity on sensitivity of dichromated colloids.

6 Study of substitute materials for plate making.

7 Practical press testing and development.

This is exclusive of special projects with private or group financing, such as:

1 Resin bonding of paper. (Now in progress at the National Bureau of Standards.)

2 Dermatitis research. (Now in progress at Kettering Laboratories, Cincinnati, Ohio.)

3 Standards and specifications for offset papers.

4 Cooperative and group research on the ink-paper-plate relationships in lithography.

5 High speed printing by web offset.

6 Blanket research.

III. Education:

1 Continuance of the Foundation publications at several technical levels, which have been and will be maintained as standard reference and research reduction-to-practice texts for the lithographic industry.

2 Training material for veterans under the G. L. Bill and for young men taken on during the war period. By January, 1946, seventeen manuals, fourteen texts, and fourteen course teaching volumes were ready, and four more teaching volumes and twenty-four Foundation texts will be added this year. The Educational Committee is recommending for 1947:
Eight craft texts.
Eight craft courses.
Four executive texts.
Four executive courses.
Eleven manuals.
Four text revisions and reprints.
Exploratory text and course for men considering career in the industry.
Special publications.

3 A Litho Training Advisory Service; help by mail and personal consulting visits to individual plants and lithographic areas.

4 Employee training courses in lithography under the auspices of the Chicago Lithographic Educational Committee with the training materials of the Foundation; opened October 1 at Glessner house.

5 Technical service in plants offered the industry: consultation on over-all problems of procedure, methods, formulae, recurring troubles, and steps to achieve greater standardization.

6 Consultation and correspondence on technical plant problems.

7 Lithographic abstracts, published monthly.

(Continued on page 50)

(Continued from page 48)

Generally speaking, research takes the directions of developing improvements in the basic integrated steps of the process, and removing human variables and wastes that produce costly make-overs and unsatisfactory quality. The program as a whole is of course tending toward standardization; and as improvements and new materials and techniques have come along new uses and new markets have opened up, which have accounted for more of the increase in volume than has diversion from other processes.

As closely as funds will permit the policy provides for a proper proportion of long-term fundamental research and advanced trouble-shooting simultaneously in the various linked chemical steps of the process: photography, color and tone correction, platemaking, and press operation.

This calls for studies in tone control and densitometric procedures; standardization of the base metals used and means of producing more uniformly grained surfaces; for studies in more uniform coatings and in the light sensitivity of coatings; and the effect of temperature and relative humidity on the printing plate, paper, ink, and the drying of ink, and press operation.

As can be seen from examination of the list of research projects currently recommended, there are problems in the pH control of fountain solutions as related to the pH of the inks and the paper and to the surface chemistry of the metal plates employed. There are problems yet unsolved in relation to the chemistry of the process throughout its parts: ink receptivity, the lithographic properties of inks, and ink and water emulsification that effects the quality of printing. Problems in relation to the dampening of the plate and the effect of temperature and humidity on the handling of paper as concerns fine registration of multi-color images are always present.

The advance through scientific research obviously should be simultaneous in the various steps of the process to keep them from becoming uneconomically out of balance.

Alois P. Senefelder, the discoverer of the lithographic process, was himself a research man who made the best use of scientific knowledge available to him. He had several failures before he reached success under the patronage of Gleissner, a musician in the Bavarian court.

In common with research men now concerned with the problems of lithography, his spirit must welcome the efforts being made to organize, finance, and make available facilities and manpower at Glessner House to create the exception to the rule that seems to prevail that science finds difficulty serving an industry sprung from an art or a craft rather than from science.

MAYBE YOU NEED A PIANO LESSON

When you look inside a piano you see a harp-shaped metal plate on which the strings are strung. Even in a spinet it ordinarily weighs well over 100 pounds.

"Too heavy!" thought Winter & Company, who make pianos. (If you've ever moved a piano, you'll agree.) "Let's have Alcoa make an *aluminum* plate."

So, Winter's piano designers and Alcoa engineers put their combined experiences together to develop an aluminum plate. First, a strong aluminum alloy had to be found because the strings put an 18-ton pull on the plate. A special alloy was produced, *but* . . .

As the strings don't pull in the same direction or with the same force, in time the plate would creep, cause distortion, and the strings get out of tune.

Alcoa engineers found a way to tell exactly where and how great the strains were . . . figured out how to balance the stresses and then stabilize the plate by an Alcoa-developed heat-treating process.

The result: The first successful aluminum piano plate, weighing only 45 pounds instead of 125, with tone quality enhanced.

That piano plate offers this lesson for young engineers to remember when they step from college into industry: Take a look at aluminum—with Alcoa engineers at your side—when you want strength with lightness in anything you are designing. Ideas click when men with imagination plus engineering—"Imagineering" as we like to call it at Alcoa—work with this versatile metal and with the greatest fund of aluminum knowledge in the world—Alcoa's. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pa.

ALCOA FIRST IN ALUMINUM

Radio Communication And It's Import In International Relations

War revealed, in a spectacular way, the vital significance of communications. In a world that is struggling for rehabilitation from the ravages of war, there is no doubt that communications represent an important factor in human affairs and in any formula for peace. All forms of electric communication—telegraph, telephone and radio—now are woven through the pattern of international relations. Of these, radio is the most powerful because of its speed and its ability to reach all nations regardless of barriers, whether oceans, mountains, deserts, frontiers or censorship. It can speak any tongue; it can speak as the voice of freedom or as the voice of dictatorship.

Radio's effectiveness depends not only upon kilowatts and wavelengths, but upon the use which man makes of it. The power of radio for good or for evil does not rest within the electron tube but within the minds of men. They determine to what use we put this modern means of communications, which encircles the globe and travels with the speed of light. Radio can move even across 240,000 miles of outer space to bring a radar signal back from the moon in less than three seconds! We have crossed the threshold of television domestically and are approaching international television. Thus we see how radio has helped to shrivel the size of the universe; we behold its great power and the challenge which science hurls at mankind.

During the war, radio did a tremendously effective job in linking the Allied armies, fleets and air armadas. The impact of war and its demands upon science revolutionized communications. Today we have at our disposal new electronic devices which make radio an even more powerful force throughout the world. By giving a fair and balanced picture of world relationships and by honest dissemination of facts and news, radio can be used constructively to help achieve a lasting peace.

For long years the portals of the British Broadcasting Company carried the inscription, "Nations Shall Speak Peace Unto Nations". But there came a day when those words over the doorway in London were illuminated by fire while exploding bombs and rockets shattered the surrounding area. Some of the missiles were even guided to the London target by radio. So we see how important it is for man in his efforts to re-establish peace throughout the world, to harness radio as a constructive aid in human affairs. Man's highest motives and hopes, including the slogan, "Nations Shall Speak Peace Unto Nations", will go for naught unless all nations use communications for peace with the same determination that they used it for war.

Today, every country realizes the need for a powerful globe-encircling voice in the post-war world. It is vital for friendship, for trade and for commerce. As part of its contribution, the United States must develop an adequate plan for international broadcasting.

When World War II began, Great Britain was at the forefront in international broadcasting through the use of its Empire system of short wave stations.

Russia, too, had erected within her borders, powerful broadcasting stations. Their programs reach all of Europe and are beamed to the East, to South America, and to other parts of the world.

Germany, before and during the war, operated a most extensive system of world-wide broadcasting. Its programs of propaganda, developed to a point of psychological warfare, were a vital part of its aggressions upon humanity.

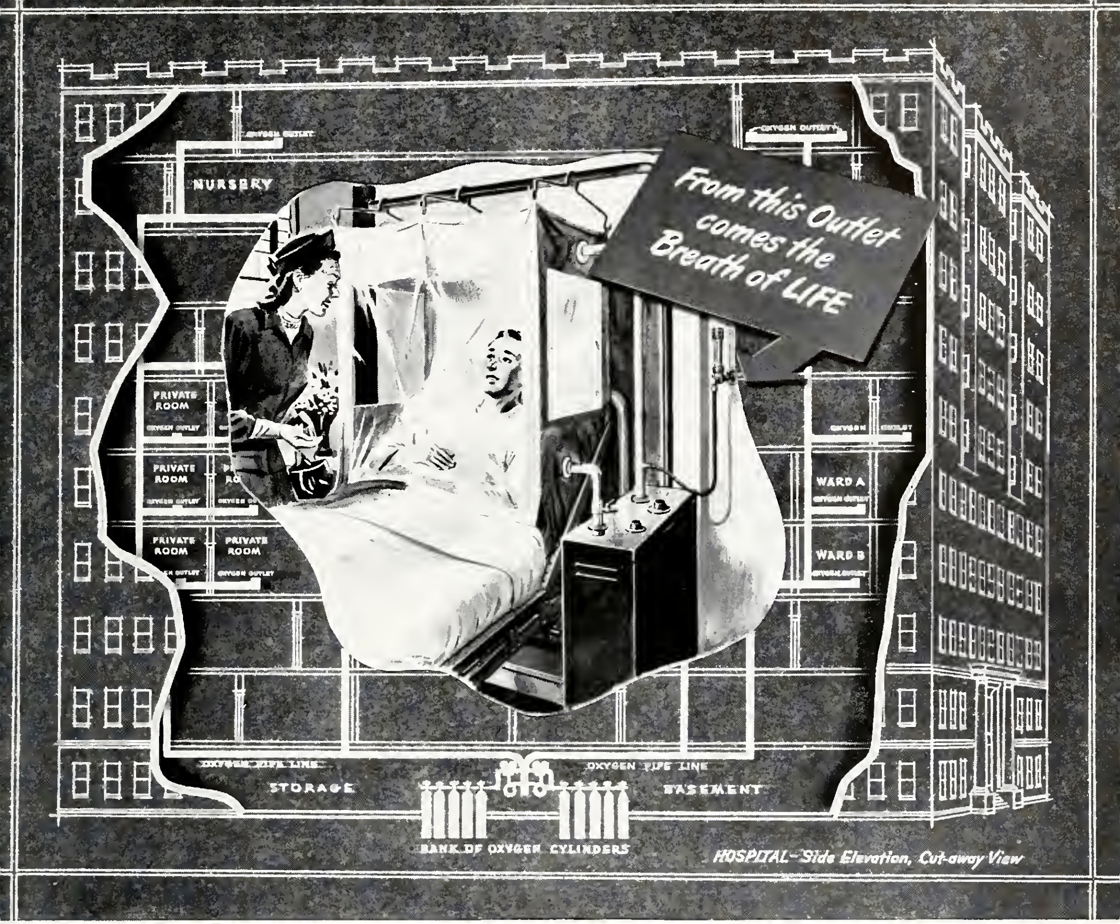
By comparison, the international short-wave broadcasting operations of America, before the war, were insignificant. During the war, a number of additional stations were erected and the service substantially expanded. The U. S. Government financed this expansion and controlled all our international broadcasting activities during the emergency.

In the brief period of one year that has elapsed since the war ended, the American position in international broadcasting has already declined sharply. Today, Great Britain continues with her International Broadcasting services reduced little, if any. Russia is actually increasing her services over those of wartime. The United States, in striking contrast, has reduced its international broadcasting services by more than one-half.

The curtailed American services are under the auspices of the State Department and are financed by a temporary grant from Congress.

The questions now facing us are these: How shall the United States continue and expand its vital service of international broadcasting so that the "Voice of America" can be heard throughout the world? Who shall control it? How can it be supported in peacetime? These questions pose new problems for our country and their solution calls for a new approach.

Address of Brig. General David Sarnoff at Princeton University Conference on "Engineering and Human Affairs", October 3, 1946. Extract.


From this Outlet comes the Breath of LIFE
NURSERY
OXYGEN OUTLET
PRIVATE ROOM
WARD A
WARD B
OXYGEN PIPE LINE
STORAGE
BASEMENT
BANK OF OXYGEN CYLINDERS
HOSPITAL—Side Elevation, Cut-away View

PROFESSIONAL

(Continued from page 23)

unions, by retail associations and a thousand-and-one others. These are the associations whose members cast the ballots that elect public officials. They have become acutely conscious of the power they possess, of the techniques of political pressure and how to achieve a political end. But many have not yet learned the implications of such power. They have not realized the measure of social responsibility inherent in such power. They are in danger of abusing it as others have abused political power in the past. So, it has been truly said that "eternal viliganee is the price of liberty."

Upon the completion of a course of training a graduating senior must inevitably become involved in this incessant human conflict. As a citizen he cannot escape it. He learns that peace as well as liberty is a difficult thing to preserve and that what one does, jointly with his associates, may hold the delicate balance between peace and strife at home and abroad. Often the strife at home is but a larger pattern of conflict which has international implications. Today, science and technology has brought all the different quarters of the globe so close together that it is impossible to isolate them one from another. In doing this science has become the greatest cultural force of our time. It cannot be ignored. Nor can it be made secondary to a study of the culture of past ages. An understanding of the past we need to give us perspective. But an understanding of what is here and now is essential to the proper perspective of the man of tomorrow.

247,000 TONS OF EXPLOSIVES MOVE SAFELY BY RAIL

Accident-Free Record Of 1945 Marks Twentieth Year Without Death Or Injury From Transportation Of Commercial Explosives.

More than 247,000 tons of commercial explosives were safely shipped over the railroads of the United States and Canada during 1945, without injury to a single person or damage to any property from accidental explosion, according to a report just issued by H. A. Campbell, Chief Inspector, Bureau of Explosives, Association of American Railroads.

"The period marked the twentieth consecutive year in which neither dynamite nor black powder has been involved in any kind of accidental explosion during transit over the rails of the two countries," the report continues.

"Increased use of explosives in the productive operations of industry for the war program made last year's achievement an outstanding addition to the already impressive record of safe transportation of explosives."

During the year 458,601,000 pounds of dynamite and 28,817,000 pounds of black powder were used in the United States and Canada. These explosives were important in agriculture, construction, mining, and quarrying. Most of the tonnage of explosives was shipped by rail. The report adds:

"Normally about 5,000 cars laden with blasting agents for industry are on the move or standing on tracks in the United States and Canada at all times, which means about one explosives car for every 60 miles of trackage.

"Organized effort to safeguard the thousands of railroad passengers and employes who daily come close to these cars began in 1907. That year exposives figured in 79 railroad accidents. Fifty-two persons were killed and 80 others were injured. Property loss amounted to about $500,000,000.

"Manufacturers of explosives and the American Railway Association launched an intensive campaign of cooperation to eliminate this loss of life and property. In 1907 the Bureau for the Safe Transportation of Explosives was established by the Railway Association with 75 railroads participating. The bureau is maintained by funds contributed by railroads, manufacturers of explosives and other dangerous articles, container manufacturers, and express companies."

Du Pont *Digest*

Items of Interest to Students of Chemistry, Engineering, Physics, and Biology

New Plastic Resists Heat, Acids, Electricity

"Teflon," Product of Group Research, is Solving Difficult Problems in Radar, Television and Industry

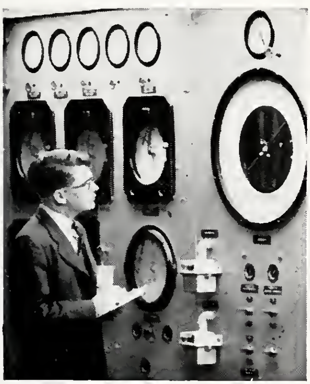
A group of Du Pont research men were looking for a new refrigerant of a particular type. These men found what they were after; but, as so often has been the case, they found something more—this time an industrial plastic whose unique qualities make it invaluable in many fields.

During the study, the chemist in charge proposed a route to the synthesis of HCF_2CF_2Cl via tetrafluoroethylene, $CF_2{=}CF_2$. In working with the latter, a chemically reactive gas boiling at –76.3C./760 mm., it was learned that it polymerized to form a resin having unusual properties.

After evaluation by organic and physical chemists, physicists and electrical experts, a suitable process for the difficult manufacture of this product was worked out by the chemists in collaboration with chemical and mechanical engineers.

Structure and Properties

"Teflon" is made by polymerizing gaseous tetrofluoroethylene to give a solid, granular polymer:



Controlled at this one panel is all the equipment for producing the polymer from which is made "Teflon."

"Teflon" (right) resists boiling acids and solvents to a degree unrivaled by other plastics.

$$n\begin{pmatrix} F & & F \\ C & = & C \\ F & & F \end{pmatrix} \longrightarrow \ldots \begin{matrix} F & F & F & F \\ C\text{-} & C\text{-} & C\text{-} & C \\ F & F & F & F \end{matrix} \ldots$$

The fluorine atoms in the molecule impart exceptional properties of resistance to heat and chemicals.

"Teflon" has unusual heat resistance. Having no true melting point, "Teflon" decomposes slowly to give the gaseous monomer and a few other gaseous fluorine derivatives at around 400°C. Under certain conditions small amounts of fluorine-containing gases have been observed at temperatures above 230°C. Because of its heat resistance, gaskets and wire insulation for jet engines are now made of this plastic. It is also used in aircraft ignition systems near sparkplugs and in high-temperature heating systems.

The chemical resistance of "Teflon" is such that it withstands the attack of all materials except molten alkali metals. Boiling in acid (aqua regia, hydrofluoric acid or fuming nitric acid) will not change its weight or properties. For this reason it may have wide use in such applications as tubing and piping for chemical plants and acid-distillation equipment.

Because the dielectric loss factor is extremely low, even at frequencies up to 3000 megacycles, it is an excellent insulating material for currents of ultra-high frequency. Its heat-resisting and aging qualities suggest immediate uses as a dielectric in coaxial cables for color television, and in radar and power fields.

Forms of "Teflon" Available

By use of special techniques the new plastic can be extruded as rods, tubes or wire coating. In general, its extrusion rates are low in comparison to other thermoplastics because of its resistance to softening.

More facts about "Teflon" are in Du Pont Plastics Technical Service Bulletin No. 13. Send your request to 2521 Nemours Bldg. Wilmington 98, Del. "Teflon" is one of the many products which represent the work and skill of Du Pont men, who, working as a team, contribute toward a better America for you and all of us.

Questions College Men ask about working with Du Pont

"WILL I STAY IN ONE FIELD AT DU PONT?"

The first position of a new man at Du Pont is based on his expressed preference and an estimate of his aptitudes and abilities. Subsequent work may be in the same or other fields, as openings present themselves in research, production or sales divisions. Keynote of Du Pont personnel policy is promotion from within on a competitive merit basis.

More facts about Du Pont—Listen to "Cavalcade of America," Mondays, 8 P.M. EST, on NBC

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...*THROUGH CHEMISTRY*

E. I. DU PONT DE NEMOURS & CO. (INC.)
WILMINGTON 98, DELAWARE

ARF—

(Continued from page 20)

The myriad of problems encountered in Mexico's expanding industry calls for consultation to gain the know-how established in other countries, training of technical personnel to meet the immediate problems, exploration to evaluate the resources natural to the country, and research to overcome the difficult problems not solved by the simpler approaches and to adapt new materials and new processes to the industry. Not every industry can afford to set up its own research organization. A research institute to serve industry is the most logical solution to this problem.[1]

Mexico is definitely industrializing. What degree of industrialization she can reach or how rapidly, it is difficult to say. The role of technology in this program is being realized by a number of leaders and they are taking active steps in the form of training technical personnel, exploring their resources, setting up standards laboratories, etc., in order to support the program with a firm technical foundation.

[1] A research institute to provide these services is described in the Armour Research Foundation report to the Banco de Mexico, *Technological Audit of Selected Mexican Industries*, by Francis Godwin, Milton E. Nelson, and Roberto Villasenor, 1946.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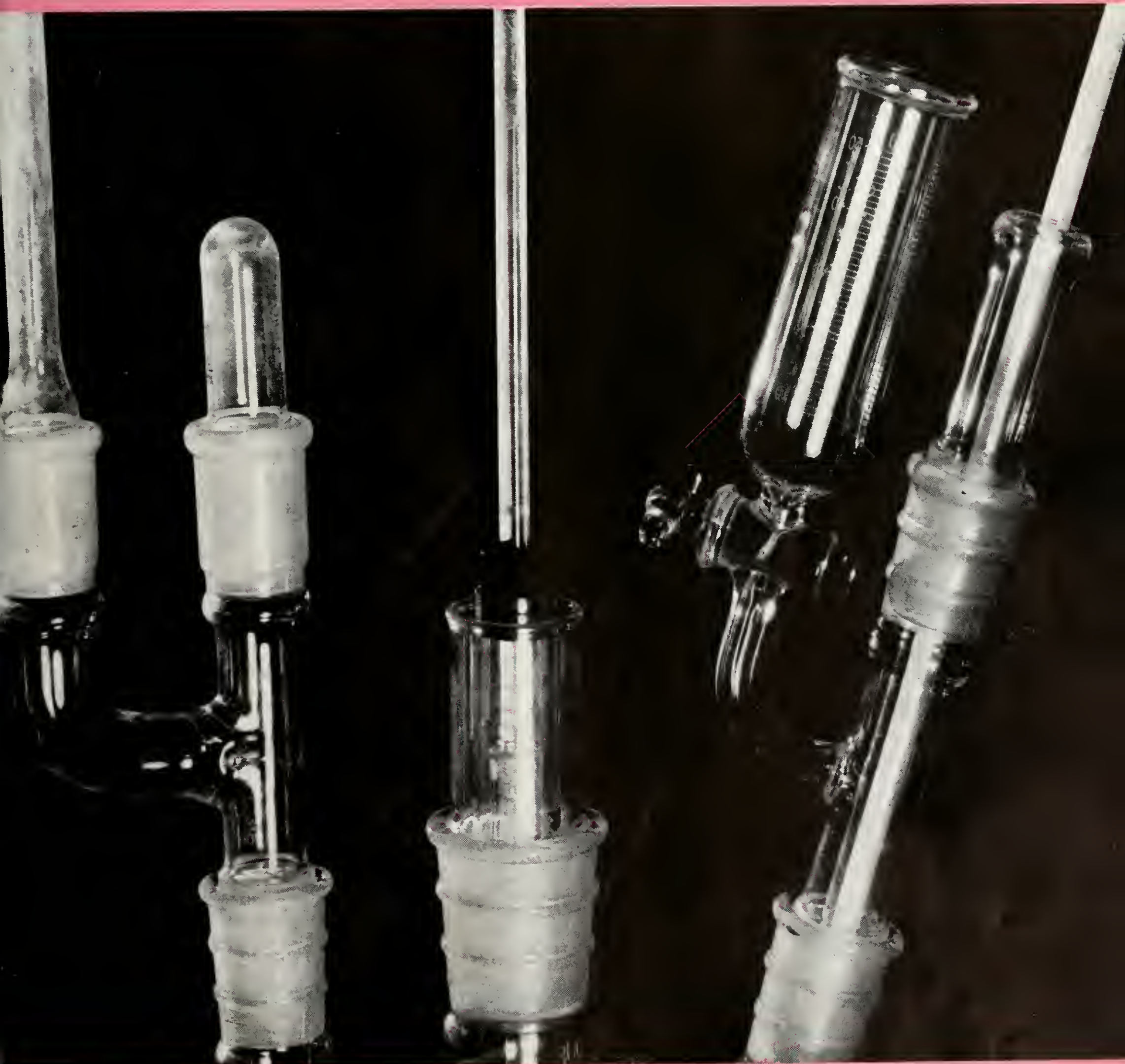

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Agness Joslyn Kaufman is one of the Registrars at Illinois Institute of Technology. At the time of the consolidation of the two schools in 1940, she was Registrar of Lewis Institute, having previously been Assistant to the Director. Miss Kaufman received her Academic Diploma as Associate in Arts at Lewis, and the degrees of B.A. and Ed.B. at the University of Chicago. She has been active in committee work in the American Association of Collegiate Registrars, and has been successively Secretary and Treasurer, Vice President, and President of the Illinois Association of Collegiate Registrars. She has received from the University of Chicago an Alumni Citation for excellence in personnel work. More than anyone else now on our staff Miss Kaufman is familiar with the history of Lewis Institute and with its spirit and traditions.

Earl C. Kubicek, Executive Secretary of The Illinois Tech Alumni Association, received his B.S. degree in Architecture from Armour Institute of Technology in 1933.

Interest in the personal papers of a great-grandfather, a Union soldier held as a prisoner in Libby Prison in Richmond, Virginia, during the Civil War, led to the study of Abraham Lincoln.

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See CONTRIBUTORS on Page 43

VOLUME 12 NUMBER 2 DECEMBER, 1946

ILLINOIS TECH ENGINEER

IN THIS ISSUE

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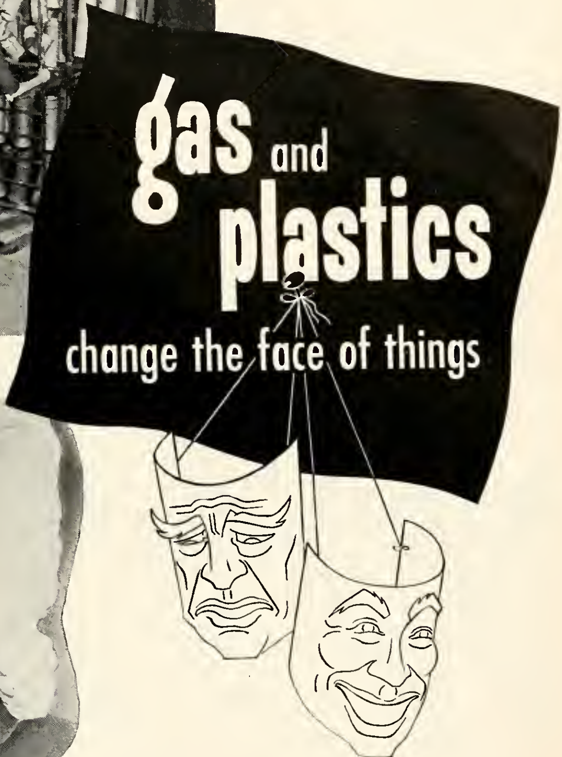

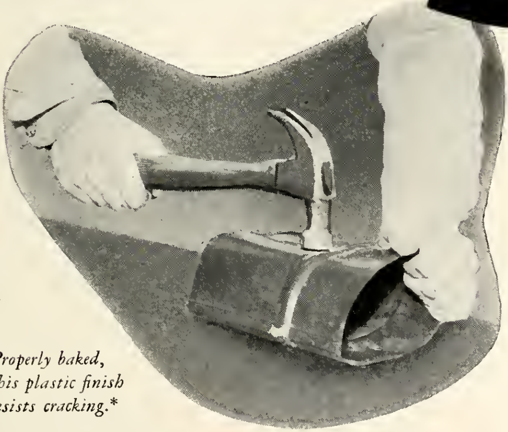

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THE CORROSION OF METALS

AN ECONOMIC PROBLEM READY FOR SCIENCE

By Hugh J. McDonald

Part I

The destruction of metals by corrosion, amounting as it does to hundreds of millions of dollars each year, is the cause of one of the world's greatest economic losses. It has been described as a billion dollar industry in reverse—all loss and no profit. Again, it has been estimated that forty percent of the entire production of iron and steel since 1890 has been lost due to corrosion. Let us consider the petroleum industry as a specific example, and give a bird's-eye view of its corrosion problem. In the United States there are approximately 333,000 miles of pipe-line transporting crude oil, refined products, and natural gas, built at an estimated cost of $3,200,000,000, which provide this nation with an underground transportation system that is a marvel to the rest of the world. Approximately 133,000 miles of this pipe-line system carries crude oil and refined products, and 200,000 miles are used to transport natural gas. On this network of underground pipe lines serving virtually ever city and industrial center in the country, it is estimated that there is an annual loss of $50,000,000 resulting from corrosion.[1]

The corrosion process itself is quiet and unspectacular with no perceptible display of heat, light or sound; only when the results become evident and someone is asked to foot the bill do we become aware of the heat and sound effects. The light is just now beginning to dawn.

Metals have been prized since the dawn of history for their luster, strength, workability and general usefulness. They are the cornerstones of the structure erected by science and industry over the past century. Yet the most useful metals are seldom, if ever, the gift of Nature. With a few exceptions they are found in the earth's crust in compound form, often as the oxide or the sulfide of the metal. They must be won from the earth and sea by the expenditure of huge quantities of man-harnessed energy. If the recovery process is reasonably efficient, a rather large fraction of this energy is captured and held by the metal.

The metals then are storehouses of energy and, in creating them, man has defied Nature and her policy of dissipating energy. Nature, as any corrosion engineer will tell you, has not taken the challenge lying down. The inevitable result, unless man exercises vigilance, is corrosion, which is simply a manifestation of the dissipation of energy stored in the metal, by the forces at Nature's disposal. It appears to be an attempt on the part of Nature to restore the status quo.

Much has been done in the fight against this evil, but no one will say that a complete solution of the problem is in sight. In the past, vast sums have been spent in search for a remedy, but much time and effort have been wasted in the hope of finding an empirical cure for a phenomenon which was not sufficiently understood. It has become obvious during recent years that the old hit-and-miss methods, by which one proceeds by trial and error, can never reach the desired goal and that it will be only by a better understanding of the chemical and physical forces which cause metals to

[1] J. C. Campbell, "Economics of Mitigation of External Corrosion on Underground Pipe Lines," *Corrosion*, Vol. 1, No. 1, 17(1945).

The photograph on the opposite page shows the outlet gates and spillway of the Columbia Basin Project, Grand Coulee Dam; note the man on the wall at the left; glassy phosphate, a corrosion inhibitor, applied to water in the conduit each time the valves are closed, has eliminated scale formation. (Reproduced through courtesy of the United States Department of the Interior, Bureau of Reclamation.)

corrode that an effective defense can be devised.

The Chemical Basis Of Corrosion Reactions

In any discussion of corrosion and its prevention, it is important to recognize that both the extent and the rate of attack will depend upon the nature of the environment as well as upon the nature of the metal or alloy.

It is generally agreed that metals may corrode by direct or indirect chemical attack or by an electrochemical mechanism. Reactions of oxygen, dry chlorine, hydrogen sulfide, and other dry gases with dry metals, and the scaling of iron and steel during hot working are examples of direct chemical attack. The attack of hydrogen on steel at high temperatures causing intergranular failure is an example of indirect chemical attack. In most cases, however, the attack on metals and alloys by water, aqueous solutions or moist air proceeds by an electrochemical mechanism.

When a metal corrodes, it is oxidized—that is, its valence is increased by the loss of electrons, and some substance in the environment is reduced—that is, its valence is decreased by the gain of electrons. To say that corrosion occurs by an electrochemical mechanism means that these two parts of the process take place on different, although usually not widely separated, areas. The area over which the metal is attacked is called the anode and that at which some substance from the environment is reduced is the cathode. If the process is to continue, an electrical current must flow between these areas through the environment, usually an aqueous solution, and between these same areas through the metal. The combination of anode areas, cathode areas, and aqueous solution constitutes a small galvanic cell and the corrosion proceeds with a flow of current analogous to the way current is generatd by chemical action in a primary cell, such as an ordinary dry battery. To understand how corrosion takes place by an electrochemical mechanism it is necessary to have some knowledge of the principles and phenomena related to galvanic cells in general.

Reactions that proceed with the liberation of energy are called spontaneous reactions because they can proceed of their own accord without the application of energy from an outside source. Oxidation-reduction reactions are reactions in which electrons are transferred from the substance being oxidized to the substance being reduced. Spontaneous oxidation-reduction reactions are therefore reactions in which liberation of energy accompanies the electron change. The displacement of cupric ions from solution by metallic zinc is a reaction of this type. The total reaction

$$Zn + Cu^{++} \rightarrow Zn^{++} + Cu$$

may be divided into two parts.

$Zn \rightarrow Zn^{++} + 2e$; oxidation of Zn.

$Cu^{++} + 2e \rightarrow Cu$; reduction of Cu^{++}

If metallic zinc is dipped into a solution containing zinc ions, and metallic copper into a solution containing cupric ions, the two solutions being separated by a porous diaphragm, the reaction does not proceed because the zinc atoms cannot come in direct contact with the cupric ions.

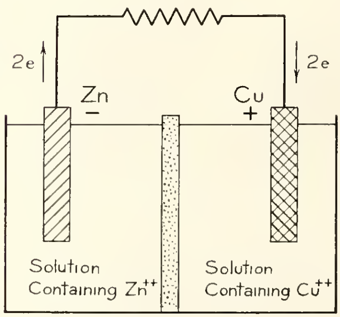


Fig. 1. Schematic diagram of a Daniell cell.

At zinc electrode (anode; negative pole of cell) $Zn \rightarrow Zn^{++} + 2e$ (to external circuit)

At copper electrode (cathode; positive pole of cell) $Cu^{++} + 2e$ (from external circuit) $\rightarrow Cu$

If, however, the metallic zinc and copper are connected by means of a conducting wire, the reaction will proceed, the electrons passing from the zinc through the external circuit to the copper where they are given to the cupric ions. This flow of electrons through the external circuit constitutes an electrical current and such a current may be used to do electrical work. This arrangement for carrying out the spontaneous displacement of cupric ions by metallic zinc with the production of electrical energy is known as a primary or galvanic cell. It will be shown later that most corrosion reactions involve a multiude of small galvanic cells.

If in a galvanic cell such as the one just described the electron change is allowed to take place only slowly, it is possible to obtain practically all the energy liberated in the oxidation-reduction reaction as electrical energy in the external circuit.

Energy liberated in reaction
= electrical energy produced
= volts × amperes × seconds

The quantity of electricity (amperes × seconds) that will flow through the external circuit when gram equivalent weights of oxidizing and reducing substances react in a galvanic cell is fixed by Faraday's law and is equal to 96,500 ampere-seconds or coulombs (one faraday of electricity). By the gram equivalent weight of an element or substance is meant the atomic or molecular weight divided by the valence change. Thus in the foregoing example the valence of zinc is increased from 0 to +2 (valence change = 2); hence by a gram equivalent of zinc is meant the atomic weight of zinc divided by 2, that is, 65.38 divided by 2, or 32.69 grams. The valence change for copper in the reaction also is 2 and a gram equivalent weight of copper is equal to 63.57 divided by 2, that is 31.78 grams. Thus for every 32.69 grams of zinc oxidized and every 31.78 grams of cupric ions reduced in the Daniell cell reaction, 96,500 coulombs of electricity will flow through the external circuit. Since the amount of electricity produced when reaction occurs between gram equivalents of reducing and oxidizing substances is the same in all cells, the differences in the energies liberated in the various cell reactions manifest themselves as differences in cell voltages. If Δ F represents the decrease in "free" or "potential" energy that

has occurred when "n" gram equivalents react, E represents the cell voltage and F denotes the faraday, the following equality may be written when the cell is discharged under such conditions that all of the available energy in the chemical reaction is converted into electrical energy

$$\Delta F = -nEF$$

Evidently, then, the cell voltage E is proportional to Δ F and a cell in which the reaction liberates a large amount of energy per gram equivalent will have a high voltage. When a cell is discharged under such conditions (that is, at an extremely low rate of discharge) that all the free energy or potential energy decrease from the reaction is converted into electrical energy, the cell is said to be reversible, and E under these conditions is called the reversible electromotive force of the cell. Thus, we may consider E (reversible) as a measure of the driving force that makes the oxidation-reduction take place; it is a measure of the tendency of the reaction to proceed or of how complete the reaction must be before a condition of equilibrium is attained.

Just as the total oxidation-reduction reaction may be divided into two half-reactions, so also may the total energy liberated in the reaction be divided between the half-reactions. Consider the reaction of zinc with an aqueous solution containing hydrogen ions at an active concentration of one mole per liter (1M)

Total reaction

$$Zn + 2H^+ (1M) \rightarrow Zn^{++} (1M) + H_2 (g, p = 1 \text{ atmos.}); \Delta F_T$$

Anode reaction

$$Zn \rightarrow Zn^{++} (1M) + 2e; \Delta F_a$$

Cathode reaction

$$2H^+ (1M) + 2e \rightarrow H_2 (g, p = 1 \text{ atm.}); \Delta F_c$$

Since the last equation added to the second yields the first equation

$$\Delta F_T = \Delta F_a + \Delta F_c$$

But $\Delta F_T = -nE_T F$; $\Delta F_a = -nE_a F$; $\Delta F_c = -nE_c F$

Hence

$$E_T = E_a + E_c$$

E_T may be measured or it may be calculated from ΔF_T. It seems impossible to obtain an absolute value of E_a or E_c, but accurate relative values are obtained by arbitrarily assigning a value of zero to E_c for the electrode reaction represented by the last of the three equations above when the active concentration of hydrogen ion in the solution is one mole per liter and the hydrogen gas on the electrode surface is at a pressure of 1 atmosphere. This means that we are assigning a potential of zero to the electrode consisting of a platinum strip covered with platinum black whose surface is kept saturated with hydrogen gas at a pressure of 1 atmosphere immersed in a solution containing hydrogen ions at an active concentration of one mole per liter. This "standard hydrogen electrode reaction" may be combined with other electrode reactions to make complete galvanic cells whose voltages (E_T) may be measured. E_T then becomes E_a for the other electrode compared to the standard hydrogen electrode. A list of single electrode potentials or standard potentials written E° for some substances important in corrosion are given in Table 1.

TABLE 1

Standard Electrode Potentials For Some Substances Important In Corrosion

	E° volts
$Mg \rightarrow Mg^{++} + 2e$	2.34
$Al \rightarrow Al^{+++} + 3e$	1.67
$Mn \rightarrow Mn^{++} + 2e$	1.05
$H_2(g) + 2OH^- \rightarrow 2H_2O + 2e$	0.828
$Zn \rightarrow Zn^{++} + 2e$	0.762
$Cr \rightarrow Cr^{+++} + 3e$	0.71
$Fe \rightarrow Fe^{++} + 2e$	0.440
$H_2(g) \rightarrow 2H^+ (10^{-7}$ mol/l.) $+ 2e$	0.414
$Cd \rightarrow Cd^{++} + 2e$	0.402
$Co \rightarrow Co^{++} + 2e$	0.277
$Ni \rightarrow Ni^{++} + 2e$	0.250
$Sn \rightarrow Sn^{++} + 2e$	0.136
$Pb \rightarrow Pb^{++} + 2e$	0.126
$Fe \rightarrow Fe^{+++} + 3e$	.0.036
$H_2 (g) \rightarrow 2H^+ + 2e$	0.000
$Cu \rightarrow Cu^{++} + 2e$	–0.345
$4OH^- \rightarrow O_2(g) + 2H_2O + 4e$	–0.401
$4OH^- \rightarrow O_2(g)$; p = 0.2 (atm.) $+ 2H_2O + 4e$	–0.391
$Cu \rightarrow Cu^+ + 1e$	–0.522
$2Hg \rightarrow Hg_2^{++} + 2e$	–0.7986
$Ag \rightarrow Ag^+ + 1e$	–0.7995
$Hg \rightarrow Hg^{++} + 2e$	–0.854
$Pt \rightarrow Pt^{++} + 2e$	–1.20
$2Cl^- \rightarrow Cl_2(g) + 2e$	–1.358
$Au \rightarrow Au^{+++} + 3e$	–1.42

Standard Potentials And Tendency Of Corrosion Reactions To Proceed

The more positive (or less negative) the standard potential, the greater the tendency of the electrode reaction to proceed in the direction in which electrons are lost. The combination of two of the single electrode reactions listed in the table, one in the direction given and the other in the reverse direction, will constitute a complete oxidation-reduction reaction. In some cases it is necessary to multiply one or both of the electrode reactions by a factor to make the electrons lost in the anode reaction equal to the electrons gained in the cathode reaction. For example, in the displacement of Ni^{++} ion by aluminum, the anode reaction $Al \rightarrow Al^{+++} + 3e$ must be multiplied by 2, and the cathode reaction, $Ni^{++} + 2e \rightarrow Ni$, must be multiplied by 3. It should be noted that even though the electrode reaction is multiplied by a factor, E° for the electrode reaction remains unchanged, because E° depends upon the energy change per gram equivalent. The positive sign of E° (total), namely $(+1.67 - 0.25) = 1.42$ volts, for the reaction means that the reaction is spontaneous; i.e. that the galvanic couple actually would supply electrical energy. If E° for a cell is negative in sign, it means that the proposed reaction is not spontaneous and that energy would have to be supplied from a source outside the system in order for it to proceed.

It seems logical that the amount of energy liberated in a chemical reaction should depend upon the concentrations of the reactants and upon the concentrations at which the products are being formed. This must be true because the potential or free energy of any substance in solution is increased as its concentration is increased, and the amount of energy liberated in a reaction increases as the concentrations of reactants in-

See CORROSION on Page 29

THE ENGINEERING MIND

of

ABRAHAM LINCOLN

By EARL C. KUBICEK

William H. Herndon, Lincoln's last law partner, in a lecture entitled, "Analysis of Character of Abraham Lincoln," delivered in Springfield, Illinois, on December 12, 1865, said of Lincoln's mind: "his mind ran back all facts, things and principles to their origin, history and first cause, and further sometimes, namely to that point where forces act at once as effect and cause. He would stop in the street and analyze a machine or other thing, mechanical or other power as exhibited in a wagon, a threshing machine, or a lightning flash . . . Clocks and words, omnibuses and language, paddle wheels and idioms never escaped his observation." He further states, ". . . in time his great logic and power of reason on cause and effect, in creation and relation, in substance and in truth, would form a proposition, an opinion wisely and well, that no human being could well deny, or ever overthrow."

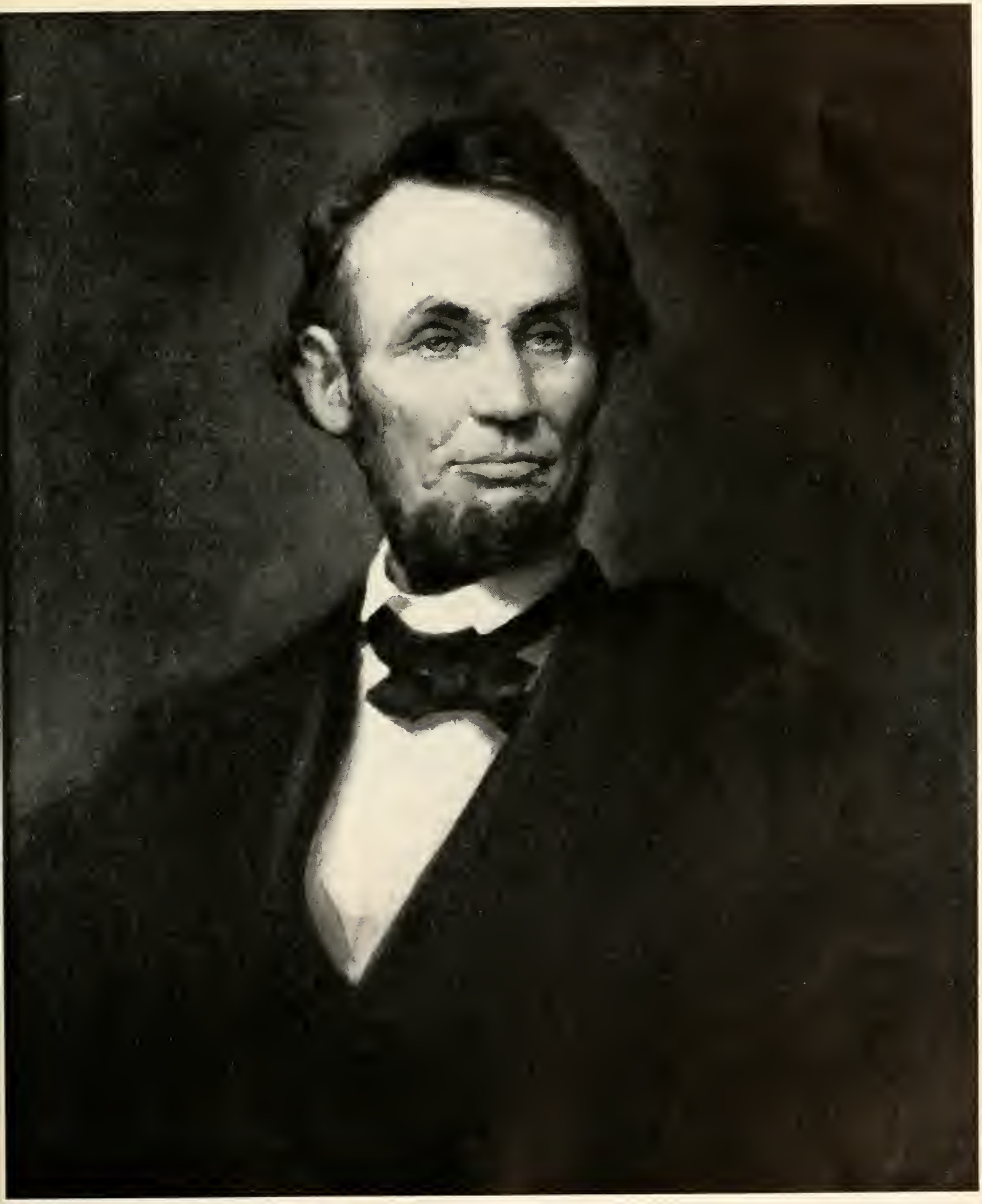
Lincoln, himself, stated his case; "I remember how, when a mere child, I used to get irritated when anybody talked to me in a way I could not understand. I don't think I ever got angry at anything else in my life. But that always disturbed my temper, and has, ever since." It is this characteristic of his mind, his direct simpleness of reasoning, his grasp of the main principles of the problem under consideration, that lead us to refer to him in relation to the engineering field. That Lincoln had enough of the mechanical genius in him to make him a good mechanic, there is no doubt. He was a builder, first in assisting to construct the log cabins in which he lived, then the flat-boats which he operated. Even after his entry into public and professional life these mechanical dreams never wholly left him. It is this story of the creative impulse in him, his deep-seated interest in things mechanical with which he came in contact throughout a broad law career and later as President of the United States, we can now consider.

Lincoln sometimes helped his father in the latter's carpentering, though he never professed any great love for the draw-knife and hammer. Lincoln and his father built a wagon for James Gentry, constructing it, "entirely of wood even to the hickory rim on the wheels." Since he had the instruction of his father, an experienced carpenter, we can well accept the statements of early pioneers concerning Lincoln's construction of a scow, which he operated near the mouth of Anderson's Creek, in Indiana, taking passengers from the shore to the steamers passing in the mid-channel of the Ohio. Thus begins the career of Lincoln, as in a rude sense, a navigator, a flatboatman.

The Ohio River, that great artery of traffic, was a passing pageantry of American life of the day. It introduced Lincoln to the life of a riverman and also introduced him to the world beyond, impressions of which were readily grasped by his mind and filed for future reference. Through his station passed the lawyers coming from the East to the wilderness, the frontier, and bringing with them the learning of books, the creed of law and order; hunters, the men of the forest, with their tales of days in the not too distant past when wild life roamed the forests in undreamed of numbers; the circuit riders, with stories of the great of their profession, Peter Cartwright and Samuel Scott and others.

These adventurers in understanding undoubtedly whetted the imagination of young Lincoln for more learning. Miss Kate Roby, who knew him in the Indiana days, tells of sitting on the river bank with Lincoln. He surprised her with his knowledge of planetary motion. She says, "He was well acquainted with the general laws of astronomy and the movements of the heavenly bodies, but where he learned so much, or how to put it so plainly, I never could understand."

A clue to Lincoln's learning might lie in his close association with those who had gone further than he in education and in his special ability to assimilate knowledge through such association. The Grigsby family—Aaron Grigsby married Lincoln's sister Sarah—all attended schools outside of the state we are told. Aaron Grigsby studied law, attending school two and



ABRAHAM LINCOLN

Painting by Penrhyn Stanlaws
Courtesy Mission Inn, Riverside, Calif.

one-half years, possibly at Hampden-Sidney, Virginia, as this was the ancestral home of the Grigsbys. Reuben Grigsby studied surveying. It is believed that Lincoln borrowed Reuben's books along with others. James Blair's granddaughter is our authority for stating that Lincoln was coached in the study of surveying by Blair, who had been educated in the East prior to his arrival in Indiana.

Lincoln's skill as a flatboatman was becoming well known and came to the attention of one Denton Offutt, an early promoter of no mean accomplishments in the Colonel Seller's type of salesmanship. He hired Lincoln, John Hanks, and John D. Johnston, Lincoln's step-brother, proposing that they take a flatboat, laden with provisions, from a place of some five hundred persons called Springfield, Illinois, to New Orleans. When his navigators arrived at the place of assembly Offutt did not have the promised boat but offered them extra pay if they would construct a craft for him. This they proceeded to do.

In Lincoln's words, "We found Offutt at Springfield, but learned that he had failed in getting a boat at Beardstown. This led us to hiring ourselves to him for twelve dollars per month each, and getting timber out of the trees and building a boat at Old Sangamon town on the Sangamon River, seven miles northwest of Springfield, which boat we took to New Orleans, substantially upon the old contract."

However an incident took place, one of several, that seemed destined to be a determining factor in shaping the course of Lincoln's life. Uneventful passage was made down the river until the New Salem dam was reached. John Hanks says, "We landed at New Salem mill about April 19th, and got fast on Rutledge's mill dam."

Here the craft seemed destined to end the journey which had begun so favorably. The boat was stuck fast on the mill dam with one end dipping into the water and the other jutting high into the air. Lincoln's inventive genius came to aid. They unloaded some of the provisions and Lincoln went into the village, borrowed an auger, bored a hole above the outside water-line to allow the water which had been shipped aboard to run out, and the craft was able to pass over the dam. They capped the hole, reloaded their provisions and, to the cheers of the assembled villagers who had gathered to watch operations and remark, "that young feller was a caution to think of such a procedure, continued their journey toward New Orleans.

The impressions of this little hamlet on a hill, gained by Lincoln during this short visit, were evidently very favorable ones for, in the summer of 1831, following his return from the New Orleans expedition, he returned to New Salem to make it his home. His jobs here were many and varied. The faith of Offutt in Lincoln was secure and he remarked to others that he'd soon have a steamboat running up and down the Sangamon and with Lincoln as her captain, "By thunder, she'd have to go." Lincoln found a short term employment with a Dr. Nelson of the village who was removing, with his family and goods, to Texas. Lincoln was hired by Dr. Nelson to pilot a vessel loaded with the household goods through to the Illinois River. Upon the arrival at Beardstown, the pilot was dismissed, after having safely brought the family through this portion of the journey, and returned, by foot, across the sandhills to New Salem.

Politics, as practiced in those days, was both a means of livelihood for those engaged in it and a source of entertainment for an amusement-starved people and Lincoln, who was always easily met and who had worked up a large acquintanceship in the New Salem vicinity on March 9th, 1832, announced his candidacy for the legislature of the State of Illinois. In view of the deep-seated interest of the community in the navigability of the local rivers and because of his intimate knowledge gained through piloting various craft on these waters, he stated in his opening speech in an appeal to the voters, "From my peculiar circumstances, it is probable that for the last twelve months I have given as particular attention to the stages of the water in this river as any other person in the country. In the month of March, 1831, in company with others, I conceived the building of a flatboat on the Sangamon, and finished and took her out in the course of the stream. Since that time, I have been concerned in the mill at New Salem. These circumstances are sufficient evidence that I have not been inattentive to the stages of the water."

In a nice admixture of political acumen and engineering experience, he expressed the idea that a railroad, connecting Sangamon County with other parts of Illinois was, ". . . indeed a very desirable object," but the cost . . . ? He discussed the geography of the river, and possibilities for improvements in its channel, and pledged himself, if elected, to support all improvements possible in measures brought before the legislature. This initial venture in soliciting public favor was not too successful but he was soon engaged in other ventures that took his mind off defeat. In the winter of 1832, a steamer, The Talisman, was advertised to leave Cincinnati and, by sailing the four rivers necessary, eventually reach New Salem bringing to the people of that community "goods directly from the East."

Men of the community, among them Lincoln, met the boat part way and helped to clear brush from along the river banks to allow easy passage. Following an extended stay at Springfield, receding waters in the river warned the officers of the steamer that the return journey should begin soon if it were to be accomplished at all. Lincoln was engaged as pilot for the craft and the return journey was undertaken, but again the New Salem mill dam intervened. A local poet described the happening:

And when we came to Salem dam,
Up against it we went jam:
We tried to cross with all our might,
But found we couldn't, and stayed all night."

This time Lincoln took no part in the negotiations that followed between the steamer's officers and Rutledge and Cameron, owners of the dam. Eventually part of the dam was taken down, the boat passed through and the incident was forgotten except in the folklore of the community.

John Calhoun, of Springfield, was

WAGON MODEL

Exact replica of the wagon model, made by Abraham Lincoln about 1840, now displayed in the Lincoln Museum, formerly Ford Theatre, Washington, D. C.

This replica is the property of Carl W. Schaefer, of Cleveland, Ohio. Mr. Schaefer, a close personal friend of the late Col. Osborn H. Oldroyd, Lincoln collector and Custodian of the Peterson House, Washington, D. C., found the model, owned by Col. Oldroyd, of such interest that he had this model made from the original.

Of the original model, Mr. Schaefer comments, "On the model made by Abraham Lincoln, which is in the Lincoln Museum in the Ford Theater, Washington, one of the steering arms was broken, and this condition existed as long as I have known of the existence of that model. It was broken at the time that Osborn H. Oldroyd recovered it from the Patent Office. Some years ago, when the Patent Office became too crowded, many thousands of models of different sorts were gotten rid of, but Colonel Oldroyd fortunately obtained the original at that time."

Col. Oldroyd and Mr. Schaefer made a patient search of the patent applications as on file but were unable to find if an application were ever filed by Lincoln, with the Patent Office, for his wagon model. The model is of much interest inasmuch as it is a forerunner of the modern automobile construction embodying a method of turning the front wheels as an independent system.

This particular Lincoln item, along with the many others of the Oldroyd Collection, became the property of the Federal Government through purchase in 1926.

At right, H. T. Heald, President Illinois Institute of Technology; center, the author.

the surveyor of Sangamon County. The constant influx of immigrants into Illinois made Calhoun's office a very busy one and he declared himself in need of another deputy surveyor. A mutual friend of Calhoun and Lincoln brought them together and, while Calhoun was a Democrat and Lincoln was a Whig, and further, Lincoln was not too well versed in surveying, Calhoun appointed him deputy surveyor responsible for all surveys in the immediate vicinity of New Salem provided he apply himself to the study of surveying and prove himself capable.

Lincoln laconically states his version of the story: "The surveyor of Sangamon County offered to depute to Abraham that portion of his work which was within his part of the county. He accepted, procured a compass and a chain, studied Flint and Gibson a little, and went at it."

This "studied Flint and Gibson a little," was no little mean chore for in Gibson's *Surveying* there are chapters on Decimal Fractions, Involution and Evolution, Geometry, Trigonometry, Mensuration of Areas, Levelling, Instruments, and so on, followed by the Tables. Mentor Graham, the village schoolmaster, says in a statement: "Lincoln came to live with me and continued with me for about six months." This was in February, 1833. Mr. Graham claims to have taught Lincoln, among other things, the rules of surveying. Graham's daughter afterward said that her father and Lincoln often sat up in the cabin until midnight, so engrossed in their calculations that they were only aroused when driven forth, by her mother, after fresh firewood to replenish the dying fire that had wholly escaped the attention of the interested scholars.

Considering past contacts with education by Lincoln, though these were of a most informal nature, and the statements of those contemporaries in New Salem, who are our authority for the statement that Lincoln read history, astronomy, philosophy, chemistry and—above all, the newspapers, during the time that they knew him in New Salem, we can well believe that his mind was prepared to assimilate the principles of surveying in an intensive course and to apply them so well to his work that no survey made by him was ever subject to questioning. When Calhoun's office as surveyor expired in 1835, his successor, Thomas N. Neale, at once reappointed Lincoln as his deputy.

In the *Sangamon Journal* of September 12, 1835, Thomas Neale advises his customers that: "I have appointed John B. Watson, Abraham Lincoln, and John Calhoun, Deputy Surveyors for Sangamon County." He gives an interesting sidelight on the customs of the time in his remarks: "In my absence, persons wishing their land surveyed, will . . . call at the Recorder's Office and enter his or their names in a book left for that purpose." He concluded his advertisement with the assurance, ". . . and their business shall be promptly attended to."

Of record are Lincoln's surveys of the towns of Petersburg, Bath, New Boston, Albany, and Huron. The early surveying records are seattered. However, it is known that three roads, three school sections, and many pieces of farm lands of various sizes are Lincoln's work.

R. B. Rutledge, a New Salem neighbor of Lincoln, gives us a word picture of him at this time and describes his usual attire: "When Lincoln was engaged in surveying he wore jeans, pantaloons, 'foxed' or covered on the forepart and below the knees behind with buckskin. This added to the warmth, protected against the rain and rendered them more durable in performing the labor necessary to his calling."

In November, 1834, it seemed that Lincoln's days as a surveyor were to end suddenly through loss of the tools of his profession. Debts were the only legacy accruing to Lincoln as a result of his days as a storekeeper in New Salem and some claims of those holding the notes of the Lincoln & Berry partnership resulted in a judgment against Lincoln. The sheriff attached his horse, saddle, bridle, and surveying instruments when he was unable to satisfy the judgment. When the articles were sold on execution, "Uncle Jimmy" Short, of Sand Ridge, one of Lincoln's New Salem neighbors and friends, bid in, secured the property, and returned it to Lincoln. A story in friendship is this little picture, for many years later when Lincoln was President of the United States and "Uncle Jimmy" had removed to California and was destitute, Lincoln heard of his condition and without any solicitation on the part of Short, returned the favor of long ago and appointed Short as an Indian Agent.

A matter of record is Lincoln's statement: "I hereby certify that the town of Petersburg has been surveyed according to law, and that this is a correct plat of the same. (Signed) A. Lincoln." John Bennett, who was the local hotel keeper in Petersburg during later years, recalled that Lincoln spent most of the month of March, 1836, finishing up the survey and the planning of the town that he had commenced the year before.

Lincoln's last recorded survey was of the town of Bath in November, 1836, for John Kerton, the proprietor. Lincoln, in a speech given at Bath on August 16th, 1858, reminded his audience that twenty-two years before he, with his own hands, staked out the town of Bath from a then wooded wilderness.

Lincoln's interest in things mechanical grew streadily, even while he was in Washington, D. C., as Congressman. We find reference, on January 21st, 1848, with the House acting as a Committee as a Whole on the private calendar, that the Congressman from Illinois, Abraham Lincoln, presented the petition of one Uriah Brown, "praying for further testing of his discovery of 'Liquid Fire', to be used in national defenses." The petition was referred to the Committee on Naval Affairs.

The return of the family from Washington was a leisurely one through New England, Canada, Niagara Falls, where Lincoln speculated on the possibilities of commercial use of the power of the Falls, westward through Detroit, and by boat to Chicago. It was on the portion of the homeward passage by boat that an incident occurred that set Lincoln's inventive mind to working on the creation of a device to be used in connection with river passage.

The boat on which the Lincolns were passengers was stranded on a sand bar. The captain, ordering the use of planks, boxes, barrels, etc., forced under the boat, succeeded in freeing the

craft. We are told of Lincoln's deep interest in the proceedings and that he made several suggestions to the officers directing operations which were accepted by them. Mr. Lincoln, immediately upon his return to Springfield from this trip made contact with one Walter Davis, a mechanic whose shop was located nearby, and arranged with him for the use of his tools and shop and assistance in making a model of a vessel incorporating Lincoln's idea conceived as a result of the operations he witnessed earlier.

Lincoln's patent application accompanying his model read, in part, "What I claim as my invention, and desire to secure by letters patent, is a combination of expansible buoyant chambers placed at the sides of a vessel with the main shaft or shafts by means of sliding spars, which pass down through the buoyant chambers and are made fast to their bottoms and the series of ropes and pulleys or their equivalents in such an manner that by turning the main shaft or shafts in one direction the buoyant chambers will be forced downwards into the water, and at the same time expanded and filled with air for buoying up the vessel by the displacement of water, and by turning the shafts in opposite directions the buoyant chambers will be contracted into a small space and secured against injury."

MEMORIAL MARKER

Photo by Author

The patent application was made on March 10th, 1849 and Lincoln was granted his patent rights on May 22nd, 1849. Herndon tells of his great interest in what he believed to be the almost unlimited possibilities of his invention and of his working on his idea in their office and explaining to him, Herndon, the principles of the whole idea. Herndon, however, did not take too much stock in his partner's idea and wrote: "This invention was a perfect failure; the apparatus has never been put on any boat so far as known." He hedged on his statements however and qualified his remarks by saying; "Although I regarded the thing as impracticable I said nothing, probably out of respect for Lincoln's well-known reputation as a boatman." The Lincoln model is now on exhibition in the Smithsonian Institution in Washington, D. C.

Patent cases, with their nice problems in mechanics and engineering, had a peculiar fascination for Lincoln. His reasoning, his power of analysis and a comprehensive grasp of the subject as a whole made him a force to be reckoned with in court.

A case in point is that of the suit, Parker v. Hoyt, an action for the infringement of a patent water wheel, which came to trial in Chicago during June, 1848. Lincoln was one of the counsel for the defendant. The defendant placed his reliance on an older patent to establish the want of novelty in the invention of the plaintiff. Lincoln took a deep personal interest in the case, using his earlier experiences in tending a saw-mill to present an argument to the jury explaining the action of water on the wheel in so clear and intelligible a fashion that the jury was able to comprehend all the points and line of defense of his side of the case. The court, in its charge to the jury, had told them in effect that the prior patent, on which the defendant was placing his reliance, was, in effect, no defense at all, but in spite of this the jury returned with a verdict for Lincoln's client. According to those who

See LINCOLN on Page 38

LEWIS INSTITUTE

By Agness Joslyn Kaufman

A history of Lewis Institute in 3000 words, Mr. Editor? It can't be done by me, but I'll try to write out some of the material that has interested me. Some of this information I have gained from old files; some bits I have heard in the households of our former trustees; of some of the incidents I can say "I was there"; but the greater part of my information came from George Noble Carman, who was Director of the Institute for forty years, and with whom I was privileged to work for eighteen years.

Lewis Institute came into existence through the will of a citizen of Chicago, Allen Cleveland Lewis, who left his estate in trust for that purpose. One of four brothers, he was the son of Jared Lewis of an old Connecticut family, and Allen was born in Sterling, Conn. in 1821 and died in Chicago in 1877. Both he and his brother, John, are buried in a vault near the old entrance to Rose Hill cemetery in Chicago. When a young man he resided in Elgin, Illinois, where he engaged in the drug business. He married and had one son who died at the age of twenty months. His wife did not long survive, and Mr. Lewis moved to Chicago and lived for many years wtih the family of a Dr. McClure in a house which still stands at the northwest corner of Warren and Damen avenues, one short block from the spot that was finally chosen as the site for Lewis Institute.

In 1874, three years before his death, his older brother, John, died and left Mr. Lewis an estate of some $350,000, the larger part of which, I understand, was invested in railroad bonds. Little is known of how Allen C. acquired the added share of the $550,000 estate he left, but the records show that, for the most part, he continued to invest in the same type of security as did John. He also acquired several large pieces of property which evidently were unloaded on him by another brother, Henry. This real estate was of dubious value at the time of his death, but fifty years later some pieces brought "tidy sums".

In the introduction to our Lewis bulletin there was a statement to the effect that "There is a trustworthy tradition that the eldest brother, John, willed the better part of his estate to Allen for the benefit of the educational enterprise". Some of our people were inclined to doubt this altruistic motive, since John's will had been made in 1856 and had never been changed, but I have talked several times with one of the McClure family with whom Mr. Lewis lived, and this Miss McClure believed that the brothers had made plans for founding some type of an institution of learning. She further remembered her father and Mr. Lewis spending many an evening around the library fire, discussing what such an institution should embrace. We know that he was greatly interested in boys who had to leave school for work at an early age, and he made several trips to Europe to become better acquainted with what he saw there in the making of adequate preparations for a vocation. Perhaps all the years spent in planning helped to create the wisdom and caution shown in the Lewis will.

It seems most unfortunate that, in those early years, no one connected with the administration of this estate thought to put in writing what he knew of the Lewis family or of Allen C. Lewis, but it must be remembered that at that time citizens of Chicago were still struggling to recover from the effects of the Chicago fire, and the first group of trustees of the Institute were probably more interested in helping to create a city out of a frontier town than they were in writing down anecdotes of a departed friend. So while we may let our imagination run riot, as we study the will, the results are still imagination. We really know nothing about the habits, character, or personality traits of Allen C. Lewis.

The Lewis will was probated in 1877 and, following an order in it to the effect that the estate must increase to at least $800,000 before a school was opened, eighteen years passed before the trustees decided "that the time had come to ask for a charter for the Institute". This is the phrase always put in print concerning this event. Perhaps, as the boys say, you would like to have the "low-down" on this situation as Judge Kohlsaat, one of our later trustees, told it. It seems to be the inalienable right of citizens of our great republic to ask, concerning public bequests — What has become of the money? Even today Chicagoans are writing to the Voice of the People asking for an accounting of the money left by Miss Buckingham to maintain the beautiful fountain on the Lake Front. Another group is questioning the handling of the Ferguson bequest by the Art Institute—a fund left to beautify the parks and drives of Chicago. And so it was that someone wrote to whatever was the Voice of the People in 1894 and asked what had become of the Lewis estate? And so, in 1895, the "trustees decided the time had come" to open Lewis Institute.

Now during this period from 1877

to 1895 the Trustees—James M. Adsit, Henry F. Lewis, and Hugh A. White—had been taking care of the estate without any profit or even glory to themselves, but they realized that they were handling a public trust and did well by the estate. In those years it had increased from \$550,000 to \$1,600,000, which amount, judged by the dollar value of that day, was a good round sum. A slightly pathetic statement issued by them, perhaps in reply to John Q. Public, says "A fact we would like to have the public bear in mind is, that although we are stockholders in other banks, we have deposited where we have no interest whatever, and where we do not get one cent on account of deposits. We draw no salary and the only cost, including clerk's hire, etc., averages less than \$1,000 per year." The record of these first trustees is certainly admirable.

Just a word as to the choice of the site for the new school. The will mentions property owned by the testator as a likely spot. This land was on what is now Wells street near Washington. The will also provided that if at the time the Institute opened this property did not seem desirable, another location might be chosen. The expansion of the city westward induced the trustees to acquire new land on West Randolph street. In time the development of the old Haymarket into a wholesale food market made this property unsuitable, and lots on Van Buren and Morgan streets were bought. Then the Metropolitan Elevated Railroad was built, and some of this land was lost by condemnation. Finally our trustees of that time — John A. Roche, Christian C. Kohlsaat, and John McLaren — purchased lots at the southeast corner of Madison and Robey streets (now Damen Avenue). Articles of incorporation were granted to them, and the will of Allen C. Lewis, visioned far ahead of the times in educational thought, became the charter of the new Institute.

Having chosen the site, the trustees started on the building before they had definitely decided on the exact type of a school it was to house. This haste necessitated changes in the plans even before the building was finished. Following the dictates of the will, it was a "good, plain, substantial building, in every way constructed for use, utility, and durability, plainly and handsomely furnished inside and out, but all extra cost for fine and showy ornamentation was studiously avoided." All of the pieces of property mentioned before were on car-line streets in accordance with a statement that "as much of the building as consistent should be devoted to general business purposes, so as to get as great an income therefrom as possible". So the first floor of the building consisted of stores, four of which in later years, were rented to the Chicago Public Library to carry out an expressed provision that a "free reading room was to be provided for the public", our own school library having proved inadequate in size. Aside from the space to be devoted to general business purposes, the will provided for the setting up of lecture halls, study rooms, and the free reading room mentioned before, which was to be supplied with newspapers and magazines of the day, and while the standard works on art and literature were to be furnished, "novels and sensational litterature were to be avoided".

The will provided for the maintenance of an evening school "with courses of a kind and character not generally taught in the public schools of the city, and with special branches or studies that would be directly useful to students in obtaining a position and occupation for life." There were evening schools, in the eastern cities at least, before this will was probated, but educators point out that the above quoted paragraph is probably the first actual provision made for adult education in the sense we know it today. In addition a "school for respectable females" was to be maintained in the different branches of art, science, design, etc., instruction in which might enable them to gain a livelihood therefrom. Even in the '70's it was evident to a far-seeing planner that men were not always going to be able to support their families and that women would have to work.

Another paragraph in the will provided for the "establishment and maintenance of a Polytechnic School, second to none, though, in no way, was this school to interfere with the school for females." All the other provisions of the will save this one are accompanied by qualifying phrases and suggestions. This statement stands alone. Perhaps Mr. Lewis foresaw the coming of this great machine age, and, being a bit vague as to how to handle such an undeveloped problem and having no desire to handicap the trustees, made a simple statement and left the rest to time. I'm wondering what he would think could he know that, after seventy years, men are still arguing as to just what a polytechnic school should be.

Much of the language of this document is somewhat quaint and old-fashioned, but the basic ideas involved are as modern as though they were written yesterday. To me it is most amusing to note that such a forward looking mind still bowed to the Victorian teachings of the '70's, for while he advocated the education of females, Mr. Lewis discouraged novels and sensational literature.

With the instructions of the will at hand, and the building started, the trustees set about to determine the nature, scope, and management of the Institute about to open its doors. Our files contain very interesting and remarkable letters from educators, prominent Chicagoans, and again from John Q. Public as to what should be taught in the new school. Several educators offered their services in opening up the new school, but the salaries they asked must have astounded the trustees as they were in line with those paid a good many college presidents today. Just as money gifts these days are almost always tagged, so each letter-writing citizen wanted a school built up that would suit his individual needs. Fortunately the trustees had the intelligence to turn for help to the newcomer in our city whose modern ideas in education were startling the Middle-West—William Rainey Harper.

Dr. Harper, who had been somewhat handicapped in the experiments he would like to have tried at the University of Chicago, eagerly seized the opportunity to develop some of his new ideas under more favorable circum-

See LEWIS on Page 43

A. R. F.

A UNIQUE TORQUEMETER

By K. W. MILLER

A need has long existed for a convenient device to measure both average and instantaneous torque transmitted by a rotating shaft. This has been attempted in the past with optical, mechanical-hydraulic, magnetic and electrical systems. Most of these devices require special insertions in, or attachments to, the shaft, force reaction through planetary gears, slip rings and/or other expensive, delicate, or cumbersome assemblies. Moreover, some of them are not well suited for instantaneous torque response.

The Armour Research Foundation is developing a torquemeter utilizing a principle devised by Mr. C. M. Rifenbergh, which will measure both average and instantaneous torque and which makes use of a small compact pickup unit which is easily installed around a short length of ordinary shaft. The torquemeter consists of the pickup unit, an A/C bridge unit, and the indicating instrument (See Fig. 1). The pickup unit, which consists of two helical coils located coaxially with the shaft, forms two arms of the bridge circuit.

A New Approach To The Torquemeter Problem

The Armour Torquemeter measures torque by detecting magnetic and electrical changes due to torsional stress in the material comprising the shaft surface. An electric current, passed through the coils of the pickup unit, sets up flux-linkages in the outer layers of the shaft. A change in stress causes a variation in the flux linking the coils to the shaft and results in an impedance change. This effect is translated by a relatively simple electric circuit means to provide a torque-proportional output current for actuation of an electric meter or oscillograph calibrated in terms of torsional stress or of any desired related quantity.

The only modification of the rotating shaft required by the torquemeter is the addition of a thin coating or metal film overlay to a short axial length of the standard shaft's surface. Means for accomplishing this by plating, metal spray, or attached metal foil covering are simple in operation and the manufacturing methods are well known. Suitable shaft coating materials and application methods for rapid and easy field application are being developed at the Armour Research Foundation. This feature is an outstanding advantage of the torquemeter—no appreciable change in cross section or addition of complex mechanism to the torque transmitting shaft is required. There are no precise or delicate parts to manufacture, install, or maintain in service.

The two stationary pickup coils, which react differentially to the resolved tension and compression components of torsional stress, are electrically identical and therefore balance out responses due to temperature and other undesired influences. They can be made very light and compact. They require but a short axial length of shaft for installation. Their design does not necessarily require complete encirclement of the shaft: comparatively large bending and/or axial stresses may be present in the shaft without appreciably affecting the accuracy of torque measurement. The pickup unit is not affected by splashing oil and does not interfere with normal means of lubrication. No physical contacts, such as slip rings and brushes, are required between the rotating shaft and the stationary pickup element external to the shaft.

Principle Of Operation

It has been known for some time that a change in the stress of certain materials will alter their magnetic and electrical properties. The Armour Torquemeter utilizes this phenomenon for quantitatively measuring the torque transmitted by a rotating shaft. The application of torque to a cylindrical bar or tube results in torsional stresses throughout its body. The maximum fiber stresses exist in the outer layers of the cylinder. The torque results in circumferentially oriented shear stresses which in turn may be resolved into component stresses—tension and compression—which are oriented respectively in the direction of right and left-hand 45° helices. It is logical to expect, therefore, that the

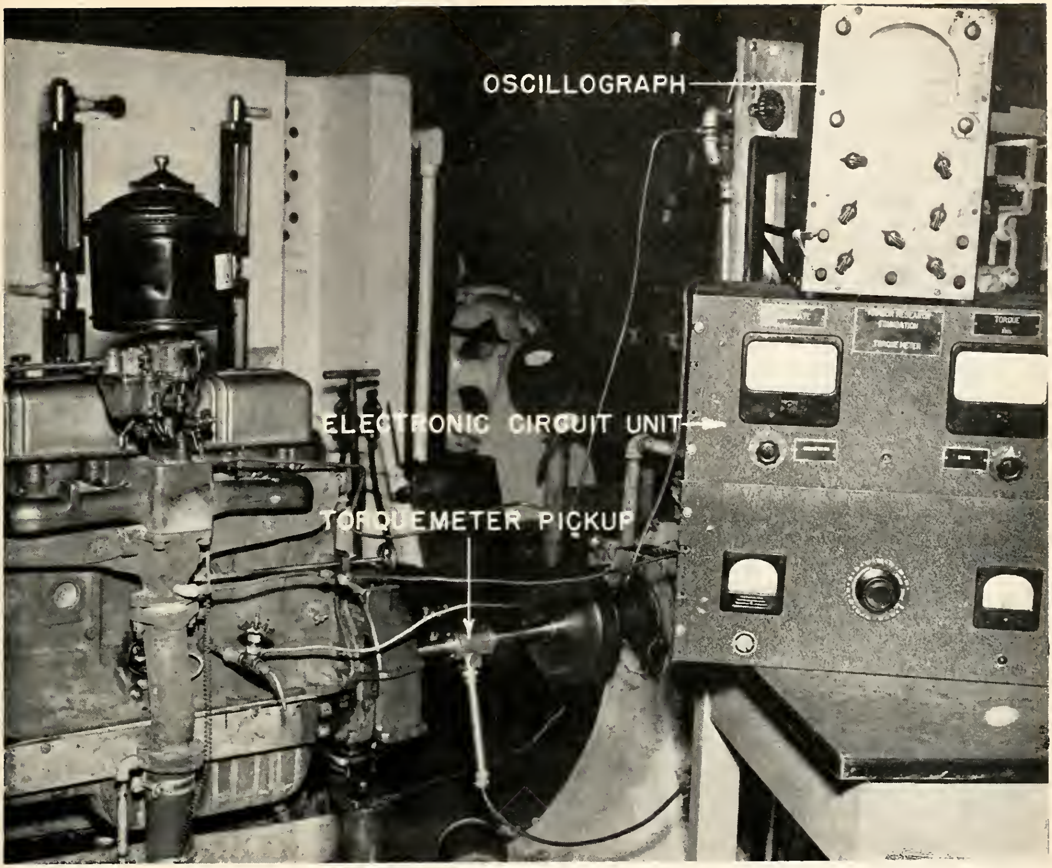


Fig. 1

maximum change in magnetic and electrical properties of the material should occur in the same 45° helix orientations. Magnetic flux is introduced in the outer layer of the shaft in similarly oriented paths by the two helical coils employed in the pickup unit. A change in the shaft surface stress brings about an accompanying change in the flux linkages between the coils and the shaft and results in a measurable change in the reactance of each coil. Thus applying a torque to the shaft can be made to produce a differential change in the impedance of the two coils. Measurement of this differential change in impedance then becomes a measure of the torque in the shaft.

Although the pickup unit is simple in construction and installation, the exact mechanism of the coupling of torque-responsive magnetic and electrical changes in the shaft material to the detecting coils is complex in fundamental nature. The net impedance change in each of the coils, resulting from torsional stress in the shaft, is the combined effect of several simultaneous reactions. Magnetostrictive phenomena involve not only a change in mechanical state, such as length, in ferromagnetic materials due to a change in the magnetic state, but conversely, the inverse effect, a change in magnetic induction, or permeability in a ferromagnetic material due to a change in longitudinal stress. The coils in the pickup introduce magnetic flux in elements of the shaft surface which may be considered as being stressed with tension and compression in mutually perpendicular directions both inclined 45° to the direction of the shaft axis. Since the shaft surface forms a part of the coil's magnetic circuit, a change in the magnetic permeability of the shaft material would appear as a change in the lumped inductance of the total magnetic circuit and cause the inductive reactance of each coil to change. All other parameters being held constant, the inductance is directly proportional to permeability. The exact magnitude of the inverse magnetostrictive effect is dependent on the magnetic intensity H, the ma-

terial itself, its heat treatment and previous history. Since the flux is introduced in the shaft material in the form of an alternate field, magnetic hysteresis and eddy current losses also become factors.

All these factors can change with torsional stress since volume resistivity and the magnetic hysteresis of ferromagnetic materials are also stress dependent. Both the hysteretic and eddy current energy losses are complex functions which can be resolved into resistive and reactive components and add vectorially with the self inductance and ohmic resistance of the coils. Moreover, for pulsating torque, small mechanical hysteresis may be present between clockwise and counterclockwise applications of torque. It is apparent from the foregoing, therefore, that the net impedance change in the pickup coils, due to a change in the torsional stress in a shaft, is quite complex. It has been encouraging, however, that torque versus bridge unbalance of the torquemeter for some materials, such as Monel, have yielded linear and reproducible relations.

The 10 KC Pickup Unit

These basic considerations have been utilized in the construction of the pickup unit. The pickup unit of the present model introduces a 10 KC alternating magnetic flux in the outer layers of the shaft. The two coils in this pickup unit are wound on laminated iron cores. The two cores each have six helical air gaps having a 45° pitch angle. The gaps in one core spiral clockwise while those in the other core spiral counterclockwise. In this manner, the flux from one core parallels the maximum tension stresses, while the flux from the other coil parallels the maximum compression stresses. The application of torsion, therefore, causes a differential change in the impedance of the two coils. The coils are placed in a housing which is positioned coaxially to the shaft by bearings. (See Fig. 1).

The Electrical Circuit

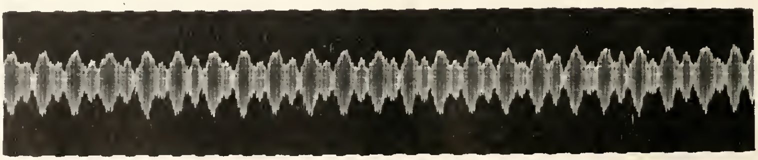
The coils of the pickup unit constitute two arms of an alternating current bridge. The remaining two arms of the bridge are contained in the electronic power source and detection unit. This electronic circuit unit contains all the necessary components for supplying the 10 KC energy and metering the bridge unbalance voltage. An oscillator of the resistance-capacity type supplies the 10 KC signal to a balanced power amplifier. The output of the amplifier is applied across the generator terminals of the bridge. A monitoring voltmeter enables this bridge voltage to be set and held to a desired value. The bridge unbalance voltage is applied to the input terminals of a frequency selective vacuum tube voltmeter which in turn supplies a meter movement and oscilloscope input channel. The average or static torque is then indicated by the meter movement which may be calibrated in units of torque or torsional stress. The oscilloscope channel supplies either a rectified modulation envelope or the unrectified modulation envelope indicating instantaneous torque on an oscilloscope for photographic or visual record. Operation of the circuit consists of setting the range switch to the desired torque sensitivity and setting the bridge supply voltage to a predetermined calibration value. The output of the instrument is of sufficient magnitude to operate standard recording instruments.

Experimental Results

Some experiments have been carried out to determine the nature of torque versus meter indication of several test shafts. Unannealed Monel tubes of various wall thicknesses have been examined and a nickel plated steel tube has been tested. The Monel shows good sensitivity and a reasonable degree of linearity in overall circuit indication, versus torque. The mechanical hysteresis in Monel (discrepancy in indication between load and unload of torque-moment) averages about one per cent. These static torque tests were run by dead loading on a torque arm welded to test shafts the other ends of which were clamped.

The stability of sensitivity and zero adjustment of this model instrument are such that torque indications may be reproduced within two per cent over periods of several hours. The torque meter has been tested under actual running conditions on two engines. One engine was a single cylinder, 4-cycle, Diesel, developing twenty horse power at one thousand RPM. The instrument gave both average and instantaneous torque indication satisfactorily for a period of one hundred and fifty hours of continued engine operation. Oscilloscope records of instantaneous torque pulsations were obtained similar in general nature to the record shown in Fig. 2. The torquemeter has also been installed on the drive shaft of standard six-cylinder

See TORQUEMETER on Page 51



OSCILLOGRAM OF TORQUE OUTPUT OF CHEVROLET ENGINE WITH ONE CYLINDER NOT FIRING

Fig. 2

WHAT IS URBAN REDEVELOPMENT?

By HERBERT A. SIMON[1]

There has been a great deal of talk during the past few years about something called "urban redevelopment." The legislatures of twenty states have placed urban redevelopment laws on their statute books, the laws of New York and Illinois being among the earliest. In broad terms, urban redevelopment is an attempt to reconstruct those large portions of our great cities that have deteriorated into slum conditions, and that are urgently in need of rehabilitation. In almost every city of the United States areas can be found. usually surrounding the central business and wholesale districts, which have fallen into a state of physical disrepair. These are also areas of "social disrepair" characterized by crime and delinquency, high rates of disease, family disorganization and poverty. On the one hand, these areas exhibit a very high density of population—at least in number of persons per room—while on the other hand, large parts of the areas are often in vacant land or in commercial and industrial use. These "blighted" areas constitute a heavy drain upon the community in terms of public services and tax delinquency. and their reconstruction has become one of the fundamental postwar municipal problems.

Urban redevelopment is of vital interest to Illinois Institute of Technology because the Institute's plant is located almost in the center of one of the most seriously blighted areas in Chicago. While the physical plant is by no means the most important part of an educational institution, and while the condition of the surrounding community cannot prevent the development of a suitable physical plant for the institution, still it cannot be denied that the community in which it lies has a considerable effect upon a school, and upon the attitudes of the public toward it. The condition of Illinois Tech's surroundings prevents it from having auxiliary services — shops, housing, and other facilities—that normally are found in a university community. Illinois Institute of Technology therefore has a large stake in the success of urban redevelopment plans for Chicago.

Causes Of Blight

Procedures for urban redevelopment will be successful only if they are soundly based upon a correct diagnosis of the causes of urban blight. While these causes are not completely known, enough is known about them to guide practical reconstruction activities.

First among the causes of urban blight is poverty. Many of the undesirable social conditions of the blighted area are simply a reflection of the general economic condition of the people who live in the area. To the extent that this is so, the poor physical condition of the area is not a cause of the social conditions, but simply another symptom of the underlying causes; nor would physical reconstruction solve these social problems so long as the underlying economic causes remained. The rents paid by the residents of blighted areas are high—measured in terms of what they get—but are low as compared with what they would need to pay in order to induce investors to provide them with satisfactory housing.

But poverty is by no means the whole story. A second factor that must be considered is land speculation. The blighted area usually surrounds a commercial district. Many of the individuals who own land in blighted areas keep it in anticipation of the eventual expansion of the commercial district. In most cases these hopes are unfounded, for the period of extremely rapid growth of our cities is over, and the blighted areas of most cities could accommodate twenty commercial districts the size of the present ones. Nevertheless, so long as the investor persists in his hope, he will not be inclined to spend very much to maintain and improve the structures standing on the land.

A third major cause of blight is the blight itself. Just as a single rotten apple will spoil a whole barrel of apples, so a few buildings in a neighborhood that are run-down, or of an inappropriate type, will start the decline of the entire neighborhood. Moreover, this is something that the individual property owner, even if he wishes, cannot do much to stop. If he lives in his own home, sooner or later he finds the neighborhood undesirable for his family and moves out. If he lets his house or apartment building, he finds that he cannot obtain rents that would justify high standards of maintenance or new investment in the property. Thus, the first symptoms of deterioration spread rapidly and ultimately bring about a deterioration of the neighborhood as a whole.

Because of the contagious character of urban blight, and because of the helplessness of the individual property owner in facing it, the condition is one that requires community action for its correction. This community action may be in the form of redevelopment work conducted by the local government, redevelopment conducted by private groups which are large enough to deal with whole areas, or some combination of these two. In general, private groups will be unable to deal with blight unless the community

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[1] The writer has no official connection with Illinois Institute of Technology's redevelopment project, nor with the South Side Planning Board. The views expressed in this article are his own.

lends them legal, financial, or other assistance. A fundamental reason for this is the difficulty of getting the large number of property owners who are necessarily involved to cooperate in carrying out any remedial scheme.

Land Assembly

A central problem in the redevelopment of blighted areas is the assembly of a sufficient area of land to permit a planned and coordinated redevelopment project. Without an area of sufficient size, new construction, no matter how well conceived, would inevitably be affected by the surrounding blight. To assemble such areas of land generally requires the use of legal powers of government.

Governmental agencies possess the power of *eminent domain*. That is, not only may they purchase property through contracts with owners, as private individuals may, but in case a property owner is unwilling to sell, or demands an exorbitant price, they may condemn the property and take it for a public purpose. Condemnation requires court proceedings to make certain that the property is being taken for a proper purpose, and to award fair compensation to the owner. The power of eminent domain not only may be exercised by public agencies, but also may be delegated by the state legislature to private individuals or corporations which need the property for some public purpose. The term "public purpose" is usually construed by the courts to mean a purpose that is sanctioned by considerations of public health, safety, or welfare. Thus railroads may be delegated the power of eminent domain to secure rights-of-way for their tracks.

Assembly of large urban land areas through voluntary purchase is an almost impossible task, since a single "hold-out" will prevent the assembly from being completed. Where assembly of even moderate areas is undertaken, the task must be surrounded with secrecy and carried out over a long period of years. Hence, the prospects for urban redevelopment through the activity of private organizations would be dim indeed if these organizations could not exercise the power of eminent domain where voluntary purchase is impossible.

One of the important functions of urban redevelopment laws is to provide legal authority for the condemnation of land needed for redevelopment. In most states *slum clearance* legislation has been on the books for some years permitting local governmental agencies to use the power of eminent domain to secure land for slum clearance and public housing programs. The new feature of the *redevelopment* legislation is that it permits this power to be used, with proper safeguards, by privately financed redevelopment corporations, or permits local governments to acquire land for later lease or sale to such corporations. Illinois has adopted legislation of both types. Thus, under Illinois law, the Chicago Housing Authority can undertake public housing projects, the Chicago Redevelopment Commission can authorize private organizations to carry out projects of their own, while the Housing Authority may also acquire and clear land for sale or lease to private organizations. The Illinois law requires that a private redevelopment corporation acquire sixty-one per cent of the land in the redevelopment area by purchase before the power of eminent domain may be used to secure the remainder.

Financing Land Acquisition

With legal difficulties out of the way, there remain formidable financial problems that must be met before rehabilitation of slum areas can be carried out. One of these difficulties is the high cost of acquiring the existing land and buildings in the blighted area. These high costs are a reflection of the high intensity of use in large parts of these areas at present, the speculative values still placed upon the land in anticipation of commercial expansion, and the fact that the value of existing structures, however deteriorated, must be completely "written off" by the project. Regardless of whether the property is acquired by voluntary purchase, or whether the price is fixed by a court in condemnation proceedings, current market prices must be paid. The very prospect of redevelopment helps to sustain land values at existing, over-optimistic, inflated values. These high costs of site acquisition are a major reason why most private housing construction in recent decades has taken place in the suburbs rather than in the more accessible and centrally-located blighted areas.

When slum clearance has been carried out by public housing authorities, the costs have been met in part through outright cash grants, or through subsidies in the form of low municipal taxes on the new housing. Substantial cash grants as well as low-interest loans have been made available by the Federal government and some state governments during the past ten years to provide housing for low-income groups and for war workers. Additional grants of this kind would be made under the terms of the Wagner-Ellender-Taft housing bill that is under consideration by Congress.

A number of redevelopment laws provide some form of financial assistance to private redevelopment corporations. This assistance most commonly takes the form of a partial tax exemption for the project. Under the New York law, for example, property taxes for twenty-five years after the project has been completed are based on the assessed value of the property prior to the redevelopment. No such exemption is granted by the Illinois law, but there is provision for cash grants from State and Federal governments for public slum clearance projects where the land may later be sold or leased to private development groups. Where tax exemption is given to private redevelopment corporations, limitations are commonly placed on the profits of the corporations—five per cent of the original cost in the case of New York.

Planning The Development

Efforts toward rehabilitation of an area cannot have more than a transitory success unless the project is so

See RE-DEVELOPMENT on Page 48

MEN OF INDIA

By K. Nagaraja Rao

There has been quite an invasion of Illinois Institute of Technology by students from India. You will find them in almost all the departments of the Institute. "Are you from Mexico" is a question which we have often been asked by those who have not seen Indians before. The veterans who were in India during the war recognize us easily and try a little Hindustani (the national language of India) on us and ask if we are from Bombay, a city which many of them had occasion to see. The telephone operator usually asks us to spell our names and heaves a sigh after finding their length. Ramakrishna, Chandran, the Srinivasans, Mahji, Almolo, Patel, and Bhagavathi have been in the school for nearly a year now. Those who have enrolled themselves this semester—they too have names difficult for you to pronounce—Narasimhaih and Panthasanathi, Iyengar, Doshi and Dalal, Shah, Kenkre and Sura are recent arrivals in this country. Don't mind the length of their names. Each name represents the name of a god, and if you address an Indian student by his name, you will have automatically pronounced the name of an Indian god. And an Indian god blesses you as well as any other. The difficulty of pronouncing names has not been an impediment in any way. On the other hand, we have received a warm welcome everywhere in America. We like the American affability and informality. Those whom we have known a little more intimately have been very friendly and extremely helpful. We bothered Dean Lewis and our respective professors, asking them to change our schedules and for so many other things. But they have always been very sympathetic, knowing as they do that we are trying to adjust ourselves to a new type of instruction.

The Indian students are here at Illinois Tech as the result of the technical training program inaugurated by the Government of India. There are at present more than 700 students in the different technical schools and colleges of the United States. India, after the war, like every other country, is planning a reconstruction of all aspects of her national life. Many plans have been formulated and many more are on the anvil, but all of them have as their objective the raising of the standard of living of the people by a well-planned industrialization of the country. The Government of India, about two years ago, decided to send 500 students to foreign countries on scholarships, tenable for two years, for advanced courses in technical and scientific subjects related to the probable post-war needs. Indian students thus selected are now taking courses in American institutions of learning in such varied subjects as helminthology, protozoology, meteorology, fisheries, wood technology, agricultural engineering, cinematography, virus entomology, and among many others the time-honored branches of engineering—civil, electrical, mechanical and chemical.

The students all have degrees from one or the other of the eighteen Indian universities and were chosen from among 13,000 applicants by committees of scientists and experts in their respective fields. The basis of selection was scholastic attainment and industrial or professional experience. The plan was sponsored by the Education Department of the Government of India and will be in operation for five years. There is also a program sponsored by the Labor Department of the Indian Government by which technicians already employed in industry are sent to the United States or Great Britain for more intensive training in the methods of the industry in which they are employed. Amongst us are also those who had enough money to spare and are here on our own resources.

All of us are taken care of by the Education Liaison Officer to the Government of India, Professor M. S. Sundaram, attached to the Indian Agency General at Washington. This "rich uncle Sundaram," as we call him, is well known to all the deans of the different schools in America. He found us places in the various colleges, arranged for our passage to this country and our accommodation here and pays our stipends. Speaking about places, we would like to thank the authorities of the Institute for so kindly providing room for us, despite the crowded condition of the Institute and the pressure on laboratories and space. It is a great gesture of good will on the part of the authorities and a symbol of American magnanimity.

It may be in place to say a few words on the Indian educational methods. There is at present a lot of illiteracy to be fought off in India. There has been a vigorous drive in the direction of providing greater educational opportunities and particular attention is being paid to vocational education. It is one of the defects of Indian education that it is bookish and in some respects unrelated to the facts of life. Too much importance is laid on examinations; they are of the essay type and have all the associated evils and some of the merits of this type. The medium of instruction is English, a foreign language, and much difficulty is felt by pupils in the early stages of learning. There is a move in all parts of India to reach the pupils in their own mother-tongue in the high school stages and some universities are also trying to do the same. The eighteen universities of India are doing work of a fairly high standard and offer courses up to the Ph.D. There are institutes of technology and a few polytechnics offering courses in applied sciences. The School of Technology of the University of Bombay, and the Benares Hindu University offer courses in

See MEN on Page 50

Safety

CAN YOU STOP YOUR CAR?

By Robert C. Peterson

Since the introduction of the motor car about the beginning of the century there has been general recognition that a large proportion of automobile accidents may be prevented if there are prompt and effective means for slowing the moving car and bringing it to a stop. During the first six months of 1946, the operation of motor vehicles in Illinois caused 876 deaths; of these, 833, or slightly more than 95 per cent, were caused by collisions. The objects collided with were as follows:

Pedestrian	369
Other motor vehicle	249
Railroad train	88
Fixed object	74
Bicycle	18
Street car	11
Miscellaneous	24

Many factors contribute to the number and seriousness of collisions. Of these factors, the one which is the main subject of this short discussion is *driver reaction time*, and the intent is to emphasize to the driver, the pedestrian, the enforcement agencies, the highway engineer, the signal engineer, and others that this matter must be properly considered as part of any successful program for reducing the number of deaths and the amount of suffering now caused by the man-created and man-controlled vehicular menace on our highways.

Psychologists may analyze and classify automobile reaction times into reflex reaction, simple reaction, complex reaction, and discriminative reaction. For the purposes of this article we define reaction time as the interval between seeing or hearing a signal or other indication of danger, and the visible physical reaction which is the proper response to the stimulus. It is obvious that the car may travel many times its own length during this short interval, and that additional time and additional distance will be needed if the situation requires complete stopping of the car.

One method commonly employed to measure reaction time and to demonstrate its relation to time-distance and braking-distance involves actual road tests in an automobile. The car is provided with a small detonating device which makes a mark on the pavement at the instant when the order to stop is given. It is simple and convincing to measure the distance from the point where the stimulus was given to the final position of the stopped car. Tests of this kind bring to the driver a real recognition of the fact that it takes an appreciable time and perhaps a considerable distance to stop a car which is in motion. His actual participation in the tests makes the results apparent to him more dramatically and more effectively than would similar results recorded on a graph or as numbers on a card.

Another method for measuring reaction time involves the use of indoor equipment of the type shown in the illustration on page 28 of the article "Safety" in the October, 1946 number of the ENGINEER. The trainee is seated in driving position with hands on wheel and foot on accelerator, and is watching a signal. When the signal changes to "stop," an automatic timing device records the time required to move the foot from the accelerator to the brake pedal. Data for the particular operator are recorded and explained in relation to traveling distance during the reaction interval, stopping distance (both at various speeds) braking distances under different conditions of the vehicle and of the roadway surface, and other variables. Since these tests are interesting in themselves, it is important that they shall not be given in such a way as to overemphasize their entertainment or competitive aspects, and thus defeat their serious purpose.

Reaction time tests do not in themselves provide a means for detecting poor drivers. Obviously, they should be used in conjunction with other tests and examinations to determine physical strength, vision, knowledge of driving rules, good driving habits, etc.

As might be expected, reaction time varies from person to person. Moreover, in the individual case it changes with age, with physical conditions, with mental state as affecting ability to ignore distractions, and with the strength or suddeness of the signal or other stimulus. It is interesting to note that, in general, older people in spite of their longer reaction time have better accident records than younger drivers. Presumably this is due to seasoning or maturing after one's first youth—the development of a greater feeling of responsibility. This does not at all affect the fact that, other things being equal, short reaction time is an advantage. Programs for testing and training youthful drivers, to the end that they may acquire skill and judgment to supplement their favorable situation

See SAFETY on Page 54

MIDWEST POWER CONFERENCE

March 31, April 1-2, 1947, Palmer House, Chicago

The 1947 meeting of the Midwest Power Conferenc will be held at its regular headquarters, the Palmer House, Chicago. on Monday, Tuesday, and Wednesday, March 31, April 1-2. This is the ninth annual meeting of the conference to be held since its reorganization in 1938 at which time the responsibility and sponsorship of the conference was centered in Illinois Institute of Technology. Cooperating with the Institute in the operation of the conference are the following universities and engineering societies: Iowa State College; Michigan State College; Northwestern University; Purdue University; State University of Iowa; Universities of Illinois, Michigan, Minnesota, and Wisconsin; the Chicago Sections of the A.I.Ch.E., A.I.E.E., A.I.M.E., and A.S.M.E.; the Illinois Section, A.S.C.E.; the Illinois Chapter, A.S.H.V.E.; the Western Society of Engineers; and the Engineers' Society of Milwaukee.

The preliminary program of the 1947 meeting is being formulated by Stanton E. Winston, conference director, with the collaboration of the conference representatives of the cooperating universities, and the following members of the staff of the Institute: Professor William Goodman, Dr. W. A. Lewis, Dr. L. T. Rader, and Dr. J. T. Rettaliata. In keeping with those of the past, the program will contain material relating to many of the fields of power, and hence be diversified in character. In addition to the Opening Session, it is anticipated that the program will include sessions on Central Station Practice, Developments in Heating and Air Conditioning, Feedwater Treatment, Developments and Problems in the Electrical Field, Fuels and Combustion, Power Plant Equipment, Hydro-Power, the Gas Turbine, Industrial Electronics, Locomotive Power Units, Diesel Power, and Industrial Power Plants. Joint luncheons with the Chicago Section of the A.S.M.E., the Chicago Section of the A.I.E.E., and the Western Society of Engineers are being arranged for Monday, March 31, Tuesday, April 1, and Wednesday, April 2, respectively. Each of these societies is also sponsoring and arranging a session of the conference program. The main event of the program, the All Engineers Dinner, is scheduled to be held on the evening of Tuesday, April 1.

The preliminary program will be ready for distribution early in February, and will be printed in full in the March issue of this magazine.

Everyone interested in the field of power and in the Nation's power problems is cordially invited to the conference. You should not miss this national power forum, a three-day conference chuck-full of power. Place the date on your calendar now.

All inquiries with respect to the conference may be addressed to Dr. Edwin R. Whitehead, Conference Secretary, c/o Illinois Institute of Technology, Chicago 16. Secure your hotel reservations at an early date.

THE SCHOOLMASTER

Propaganda. Hayakawa, in *Language In Action*, writes of "snarl-words" and "purr-words." "Propaganda" seems to most of us to be a snarl-word; if not quite that, it indicates at least that we are looking down our noses. Nothing written here will change the common usage. The word will continue to indicate biased argument, slanted reports, and suggestions intended to influence our opinions and our actions in a direction which is probably not good for us or the community, but which is desired by the propagandist in his own interest or the interest of his group. In its derivation, the word has no unfavorable suggestions, but of course it means now what we agree that it shall mean. That is an over-simplification, but the Schoolmaster has neither the time nor the other qualifications for adequate semantic discussion.

Just for fun, let's see if we can justify propaganda for propaganda. Immediately we are in trouble, because the word has become spoiled. But "propagate," in several senses, is not a snarl-word. We may propagate the principles of religion, ethics, democracy, industry, thrift, or good manners; or we may propagate wrong-doing, tyranny, cruelty, crudity, or carelessness.

We at the Institute are a community of several thousand people. Let's pretend for the moment that "propaganda" is a purr-word. (After all, the ancient College of Propaganda is for propagation of the faith.) And without any sanctimonious attitude, and without raising questions of "my-doxy" and "your-doxy" is not propaganda a part of the job for most of us? What about the honor system? It is a good plan, and on the whole it seems to be better than other systems in protecting the square-shooter against the chiseler. What about a little more propaganda for the honor system? Pending the completion of more of our new buildings, we are uncomfortably crowded. Courtesy and a reasonable degree of quiet, especially in the intervals between classes, adds greatly

See SCHOOLMASTER on Page 52

CORROSION

(Continued from page 11)

crease and as the concentrations of products decrease. Applied to the case of the galvanic cell, this means that the voltage of the cell will increase as the concentrations of reactants increase and the concentrations of products decrease. Any electrode becomes less anodic as the concentrations of the products of the electrode reaction are increased and as the concentrations of the reactants are decreased.

It is always important to know whether a specific metal can react spontaneously with a specific environment. For example, for many years much time was spent in debating the question, "Can pure iron react with pure water if oxygen is absent from the system?" Today it is possible to answer such questions with reasonable certainty in most cases because data usually are available that permit a calculation of the change in free energy accompanying the proposed reaction. As has been indicated, the reversible electromotive force or driving force of the corresponding corrosion couple may be calculated from the energy change. If the calculated voltage is positive, the proposed reaction can occur; if it is negative, the corrosion reaction is impossible under the conditions postulated. It is instructive to consider the results for a number of common metals on the assumption that they corrode to form solid corrosion products in two of the most common environments, namely, in water with oxygen absent, and in water saturated with air (assuming air contains 21 percent oxygen, that is, the partial pressure of oxygen equal to 0.21 atmospheres). If a metal corrodes in oxygen-free water, hydrogen must be displaced; therefore this type of corrosion is referred to as "hydrogen type". Corrosion in water in the presence of oxygen is called "oxygen type".

Calculations[2] show that magnesium, aluminum, manganese, chromium, zinc, and iron can corrode to form a solid corrosion product (water is saturated with the oxide or hydroxide) even in the absence of oxygen. Iron can corrode in oxygen-free water to form ferrous hydroxide or to form magnetite, Fe_3O_4, but cannot form ferric hydroxide. Cadmium, cobalt, nickel, lead, copper, mercury, and silver cannot corrode in oxygen-free water, but all of the above metals, extensively used in industry, can corrode spontaneously in water saturated with air. This fact emphasizes one important aspect of the whole corrosion problem; namely, since the corrosion of almost every metal in the presence of water containing oxygen is spontaneous, the real problem is one of understanding the factors that control the rate of discharge of the galvanic corrosion couples so that steps may be taken when possible to decrease the corrosion rate.

Some Causes Of Corrosion Reactions

The causes of corrosion reactions of the electrochemical type are all factors which lead to differences of potential between two metals or between two or more points on the same metal. A number of these factors,[3] responsible for potentials which in turn lead to corrosion, are taken up in the following paragraphs.

NATURE OF THE METAL ITSELF

Let us consider first, the potential differences associated with the metal itself. The appearance of specimens suffering electrochemical corrosion suggests at once that the attacked areas differed from the unattacked areas. Actually, none of the commercial metals or alloys are entirly homogenous, so that small particles of other phases may often be detected upon microscopic examination. In some alloys two or more phases are often desired in order that certain physical properties will be obtained. If the various phases can be identified by chemical, spectographic, X-ray or electron diffraction means, the solution potentials of larger pieces of these phases can be measured in the solutions under consideration against a standard reference electrode such as the 0.1 normal calomel cell. It is also possible, by means of a moistened fiber, to measure the solution potential of the separate phases directly in the experimental specimen.

Practically all metal parts of a size which is commercially important are made up of a multitude of individual grains or crystals. It is clear that the boundary between any two grains is a region which is definitely heterogeneous compared with the body of the grain. Not only does the orientation of atoms in adjacent grains differ, but also small particles of separate phases usually precipitate out of solid solution selectively at the grain boundaries. In those cases where the grain boundaries are anodic to the grain centers, attack will be of an intergranular nature; whereas in cases where the grain boundaries are cathodic to the grain centers, the grain centers will be selectively attacked and the grain boundaries will stand out in relief, resulting in an attack of a granular nature.

Grains oriented in different directions would be expected to have different solution potentials. Also, a fine-grained specimen of a given metal contains a higher internal energy than does a similar coarse-grained specimen, and for this reason it would be expected to exhibit a different solution potential.

If one portion of a metal surface has been subjected to a different thermal treatment from that on other parts of the surface, differences in potential between the two regions may occur. Under service conditions the heat of welding is likely to cause some inhomogeneities. In this case it is not generally the weld bead which is anodic, if the weld wire used was of the same alloy as the material being welded, but usually a zone on either side of the weld where the metal was heated and cooled at some optimum rate which would throw cathodic impurities out of solid solution. Whenever local heating results in changing the nature of the phases present, or their compositions, difference in potential will probably occur.

[2] J. C. Warner, "Thermodynamics of Corrosion Reactions," *Trans. Electrochem. Soc.*, Vol 83, 319. 1943.

[3] R. B. Mears and R. H. Brown, "Causes of Corrosion Currents," *Ind. and Eng. Chem.*, 33, 1001, 1941.

NATURE OF THE METAL SURFACE

Potential differences associated with the metal surface will now be taken up. Highly polished metal surfaces may exhibit different solution potentials from those of rough abraded surfaces. Probably one reason is that any film which forms on a rough surface will be much less continuous than a film formed on a smooth surface. Potential differences caused by local scratches or abrasions are related to those just discussed. Such potential differences are among the most important causes which determine the sites of local attack. As might be expected, the effect of scratches in determining sites of attack is most pronounced in environments where the metal in question forms adherent and protective films of corrosion product. Obviously, if the entire metal surface is attacked and the corrosion products which are formed are soluble, scratches may not be points of special weakness. Therefore, this phenomenon is most in evidence when the metal in question resists attack by forming a protective layer.

Cut edges are also sites of special weakness under many exposure conditions. Several factors contribute. In the first place, because of geometrical considerations, it is generally more difficult for a continuous protective film to build up over the edges. Often the edges are rough and uneven, and there are ragged and torn metal fragments which have a large ratio of surface area to volume. In addition, if the material was sheared, the edges have been subjected to severe cold working which may also cause them to be more readily attacked in certain environments. It is important to emphasize, however, that cold working does not always produce special susceptibility to attack; in fact, cold worked materials may actually prove more resistant than annealed materials in certain cases. Thus, it is not possible to predict with certainty whether or not the edges or center of the specimen will be more susceptible. However, it is a general rule that the edges will probably behave differently from the center.

The shape of the specimen may sometimes be of controlling importance, as might be inferred from the preceding paragraph. Convex surfaces generally show lower hydrogen overvoltages than concave surfaces and so may develop different solution potentials. It has been shown that wires of small diameter corrode more rapidly than wires of larger diameter.

In the section on cut edges, it was mentioned that strain hardening may contribute to special edge attack. Such behavior may not be confined to edges. Any portion of a specimen subjected to plastic deformation may have a different solution potential from a similar specimen which has not been deformed.

If a portion of a metal surface is exposed to some environment which differs from that to which adjacent areas of the surface are exposed and then subsequently the entire surface is exposed to a uniform environment, corrosion currents may flow between these areas. Suppose that a drop of hydrochloric acid falls on a metal surface. At the local area in contact with the acid the natural protective layer may be broken down. When the entire specimen is subsequently exposed to a salt solution, attack may be confined solely to the small area which had previously contacted the acid.

Conversely, a portion of the metal surface may be exposed to air, oxygen, boiling water, or some environment which causes the formation of a protective film. On subsequent exposure to salt solution, a substantial potential difference may be set up between the film-free and the film-coated regions which will result in special attack.

NATURE OF THE IMMEDIATE ENVIRONMENT

In addition to corrosion currents set up by heterogeneities in the metal itself or on its surface, heterogeneities in the corroding environment may also be important. Heterogeneities which have probably caused the greatest difficulty under service conditions are those which result from differences in concentration in different portions of the corroding liquid.

When one metal specimen is immersed in a salt solution of a given concentration and another similar specimen is immersed in a salt solution of a different concentration, the solution potentials of the two specimens will generally differ. This means that if different portions of the same specimens are exposed to different concentrations of salt solution, corrosion currents will probably flow between these areas.

If different amounts of oxygen are dissolved in different portions of the liquid which are in contact with a metal surface, special attack is likely to occur at those areas in contact with the liquid of lowest oxygen concentration. There are some exceptions to this rule; for example, with copper, the aerated specimen is anodic. This "differential aeration effect," which is similar to the differential concentration cells just discussed, is of great practical importance. Thus, if some inert absorptive mass is pressed against a portion of a metal surface which is immersed in an aqueous solution, less oxygen can diffuse to the screened portion. As a result, corrosion currents are set up between the screened and the unscreened areas. This may result in extremely rapid local attack.

In certain service exposures, one portion of a metal surface may contact liquid at one temperature while another portion of the same surface contacts liquid at another temperature. As might be imagined, such differential heating can cause corrosion currents, since the different metal areas develop different solution potentials. In general, the specimen in the hot solution is anodic.

Local illumination of some portion of a metal specimen which is immersed in a solution can cause the illuminated portion to exhibit a different solution potential from that of the adjacent unilluminated areas. The illuminated surfaces generally have been reported as being cathodic—a result which has not been satisfactorily explained to date. The presence of some dissolved oxygen in the solution increases the action of the light. Evidently the effect is not the result

(Continued on page 32)

(Continued from page 30)

of local heating at the illuminated surface, since, as discussed above, the heated surface would become anodic. Potential differences of the order of 0.1 volt have been reported as resulting from differential illumination, and the effect has been noted for aluminum, copper, lead, zinc, and several other metals. Potentials of this order of magnitude are quite sufficient to cause severe corrosion when maintained for an appreciable length of time.

Stirring the liquid in the vicinity of a portion of a metal surface more violently than the liquid near other portions is stirred can cause corrosion currents. This effect, known as the moto-electric effect, is especially troublesome in ships, propellor blades, and in pump impellers. If the stirred liquid is under an air or oxygen atmosphere, differential aeration effects will also come into play, since agitation of the liquid will bring more oxygen into contact with the metal in a given length of time than if the liquid is not agitated. The moto-electric effect may be due to the removal of ions in the saturated layer next to the anodic area and the consequent attempt on the part of the system to maintain equilibrium between the corroding metal and the solution.

For copper, the specimen in contact with the stirred solution is anodic to the specimen in contact with the quiescent solution. For iron and aluminum the reverse is true. Apparently the differential aeration effect incidental to agitation in air is more important for the latter metals, while for copper the removal of dissolved copper ions from the liquid layer adjacent to the metal surface causes the specimen in the stirred liquid to be anodic to the other.

Corrosion currents of substantial magnitude may be caused by contact between different metals (galvanic corrosion). It is important to stress, however, that the electromotive force series is not dependable as a basis for predicting which metal of a couple will suffer galvanic attack when coupled to a different metal and exposed to a solution. The reason is that the solution potentials of the different metals change as the solution in which they are exposed is changed. Thus, in order to be certain whether or not contact between metals A and B will result in galvanic attack of metal A, it is necessary to measure the potentials of these metals in the particular solution under consideration. However, in most neutral tap waters or salt solutions, especially if these solutions contain some chlorides, the behavior of the various metals can be predicted fairly accurately from their solution potentials measured in a sodium chloride solution.

The potential difference between the two metals is a measure of the driving force tending to cause corrosion currents, but the magnitude of these currents is the only true measure of the velocity of chemical attack. High currents are not necessarily associated with large differences in solution potential because of film formation or other polarization effects at the metal surfaces.

Another factor influencing the magnitudes of galvanic currents is the relative area of the two specimens composing the couple. A large surface area for the cathodic metal will result in a higher current density, and consequently a higher corrosion rate, on the metal which is being attacked than if the surface area of the cathodic metal were very small. Thus it is generally safer to use rivets of a cathodic metal or alloy in a structure which is anodic to them rather than the reverse.

Another type of corrosion cell closely related to that discussed above is formed when a metal specimen is exposed to a liquid containing reducible ions of a more cathodic metal. Thus, if a platinum salt is added to dilute hydrochloric acid, the resulting solution is much more corrosive to zinc than is a hydrochloric acid solution of the same concentration but not containing any platinum. Additions of salts of other cathodic metals (nickel, gold, cobalt, copper, bismuth, antimony, silver, and iron) are also effective in stimulating attack. Under these conditions the various cathodic metal salts are reduced, and particles of the cathodic metals are deposited on the zinc surface and hence create a multitude of tiny galvanic cells.

EFFECT OF EXTERNALLY GENERATED POTENTIALS

Currents caused by externally generated potentials are responsible for certain severe cases of corrosion. Probably underground structures are those which suffer most from attack from this source. However, such cases are now becoming less prevalent, since they were often associated with stray currents from the track returns of street railway systems. Pipe lines or lead-sheathed telephone or electric cables paralleling electric railway tracks often served as conductors for some of the return current. In the case of steel pipe lines, regions of the pipe which receive current flow from the surrounding soil are not attacked, but at points where this current leaves the pipe to return to the track, severe electrolytic attack may occur. Since stray currents of this type may be of much greater magnitude than the currents generated locally on a metallic structure, corrosion from this cause can be extremely rapid.

While the regions of steel structures which receive current flow from the soil do not corrode, this is not always true in the case of structures made of amphoteric metals, such as lead, zinc, and aluminum. For the latter metals current densities in excess of certain amounts may cause special attack of the cathodic metal areas, since the soil, or solution, adjacent to such regions may become definitely alkaline. Such cathodic corrosion of lead cable sheath has given trouble in several instances.

The discussion has been confined to the effects of direct currents. However, alternating currents can also cause electrolytic attack, at least in some cases. A few metallic oxides allow current to pass more readily in one direction through the oxide-metal layer than in the reverse way; for example, with copper, current flows more readily from the copper-oxide

(Continued on page 34)

Photomicrograph of a snowflake

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(Continued from page 32)

layer to the copper than in the reverse direction. In such instances, alternating current may be so changed as to cause quite severe corrosion. In the case of alternating currents the frequency is also important. At relatively high frequencies (above several cycles per second), in many instances apparently the amount of metal redeposited during the period current flows from the soil to the structure exactly counterbalances the amount of metal dissolved during the reverse cycle. Therefore the corrosion losses from this cause are negligible. However, for other metals under these same conditions, little or no metal is redeposited once it is dissolved, and therefore corrosion may be severe. As the frequency is reduced, metals may corrode more appreciably.

CORROSION INVOLVING MICRO-ORGANISMS

It has been noted that the corrosive action of sea water is much greater than that of artificially prepared sea water containing the same salt concentration and that the corrosive action of natural sea water is substantially reduced if the water is sterilized. This would seem to indicate that micro-organisms may be responsible for the difference in behavior.

Many investigators have drawn attention to the fact that the corrosive layer which accumulates on iron which has been long immersed in certain waters, notably sea water, or buried in certain soils, especially those of the clay type, contains a high proportion of sulfur as sulfide of iron. The amount of sulfur in such cases is much in excess of that present in the metal or of the hydrogen sulfide content of the surrounding medium. In all such cases, however, the water or soil contains sulfates, and the question arises, as to how the sulfates are reduced to sulfides. No satisfactory chemical hypothesis has been advanced, and there is much evidence to support the view that reduction is brought about by

(Continued on page 36)

NUMBER 4 OF A SERIES

Newsworthy Notes for Engineers

Cooking handsets with Radio Waves

After V-J Day, the demand for telephone equipment was at an all-time high. Total requirements for telephone handset handles, for example, were 33 per cent above the highest previous production rate. New molding presses would not be available for many months. It was up to Western Electric engineers to find a way to make these important parts *twice as fast* as they had ever been made before. So they called on wartime experience with electronic pre-heating of plastics—cooking with radio waves.

The method formerly used to produce the handles was to mold granular plastic into solid handles with conductor wires imbedded in them.

In the new method, granular plastic is first molded into a "pre-form", about the size and shape of a hockey puck. These forms are then "cooked" or heated to the consistency of butter by subjecting them to high frequency current—then placed in molds for final shaping. The new handles have hollow cores through which the insulated conductors are pulled.

This method doubles the output of handles, increases strength due to more uniform heating, improves finish, reduces amount of material used.

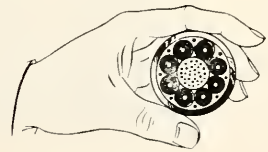
Coaxial Cable by the mile

To meet future needs for long distance telephone and television circuits, the Bell System is constructing a nationwide network of coaxial cable. Ingenious machines designed by Western Electric engineers are now turning out coaxials like spaghetti.

A coaxial unit consists of a copper wire supported centrally in a copper tube by plastic disc insulators. The copper sheath is covered by two layers of steel tape.

One machine punches out the plastic discs. A second machine feeds the discs through chutes onto wheels which force them onto the wire at precise intervals. The wire then travels through mechanisms which notch and form the copper tape around it and finally apply the double wrapping of steel tape.

All these processes are carried on continuously. Copper wire goes in one end of the machine—complete coaxial units come out the other end.



A cable like this, with eight coaxial units, can carry as many as 1440 telephone messages simultaneously—can handle television frequencies up to 2,800,000 cycles per second.

It takes 17,000,000 insulated pieces to make one part

It sounds fantastic—but it's one of the unusual feats accomplished by Western Electric engineers in producing compressed powdered cores for inductance coils used in the Bell Telephone System.

Thin "overcoats" of an insulating material are put on *every particle* of the molybdenum-permalloy powder of which the cores are made. The particles—averaging about 40 microns or 1½ thousandths of an inch in diameter—are coated with a minimum thickness of insulating material by precisely controlled mixing.

The resulting film has to meet three major requirements: It must not break away during compression and heat treatment of the core; it must isolate the particles electrically to reduce eddy current loss; it must remain chemically inert throughout the lifetime of the magnetic core.

Developing quantity manufacturing processes calling for scientifically controlled laboratory precision, is an interesting part of the complex, high quality production job for which Western Electric has long been noted.

Manufacturing telephone and radio apparatus for the Bell System is Western Electric's primary job. It calls for engineers of many kinds — electrical, mechanical, industrial, chemical, metallurgical — who devise and improve machines and processes for large scale production of highest quality communications equipment.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

(Continued from page 34)
micro-organisms which depend upon the reduction of sulfates to sulfides for their normal life functions. Moreover, it has been found that the brine which accompanies most crude oils is a carrier of this type of micro-organism, and it seems quite possible that these are responsible for some of the corrosion which is usually attributed to the brine itself.

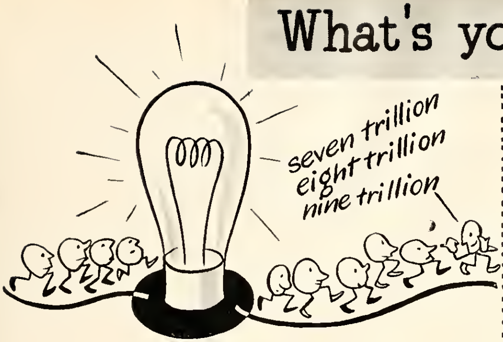
It is also established that other micro-organisms in the presence of vegetable matter will produce organic acids which reduce the pH value of the soil. A low pH value, other things being equal, will always increase the rate of corrosion. This type of attack can be quite a serious problem in the case of pipelines and other metallic components which are of necessity buried in the earth.

Tests on buried specimens have shown that the depth of pits which develop on the specimen varies roughly with the acidity of the soil and inversely with its electrical conductivity. In the case of a pipeline or other buried metal of considerable dimensions it is inevitable that the dissolved oxygen concentration in the moisture of the soil will vary from place to place. This will result in an electric current flowing through the soil from the region of low concentration to that of a higher concentration, returning along the metal part. Corrosion will occur at the point where the electric current leaves the metal to flow into the earth, and, while very little can be done to reduce the conductivity of the metal, that of the soil is another matter. In some cases the removal of the soil and its replacement by soil showing better characteristics on these two points has proved to be a good economic move. The pH value of the soil chosen should not be lower than 7 and the higher the electrical resistance, the better.

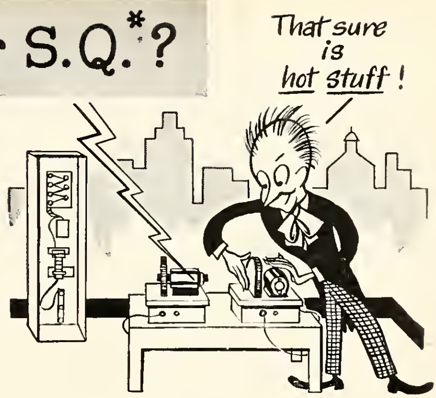
In many forms of hard water, the dissolved salts are not confined to carbonates and sulfates—the nitrate and chloride of calcium or magnesium, or both, being present. These, although present in relatively small quantities and not contributing materially to the deposit due to carbonates (formed by the thermal decomposition of the soluble calcium and magnesium bicarbonates) are corrosive in their action, and the problem is made worse by the fact that they are not so readily removed by the ordinary water-softening processes and are not dependnt upon heat for their injurious action. In radiator systems, where the trouble is likely to be most serious, the corrosive attack due to the presence of these salts may be substantially reduced by the addition of sodium hydroxide to the water at the rate of about one ounce to the gallon.

The concluding portion of this article will appear in the March, 1947, issue.

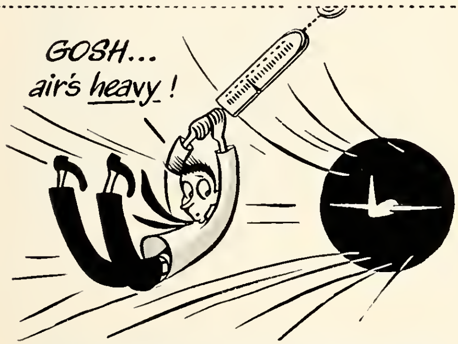
What's your S.Q.*?



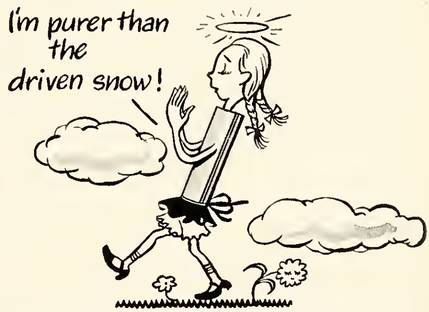
1. WHAT IS THE TOTAL WEIGHT of the electrons flowing through a 100-watt lamp filament, burning continually for one year on a 115-volt circuit—(a) 150-billionth ounce, (b) 5460-millionth ounce, (c) 2⅜ ounces?



2. WHAT IS THE AMPERAGE of the average thunderbolt—(a) 20,000 amperes, (b) 1,700,000 amperes, (c) 4,000,000 amperes?



3. AIR PASSING THROUGH the experimental wind tunnel at Wright Field, during a single hour, weighs as much as—(a) Army "jeep", (b) electric locomotive, (c) medium-size ocean liner?



4. THE PUREST FORM of iron ever produced is used in—(a) arc-welding electrodes, (b) thermostatic controls, (c) spectrum analysis?

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ANSWERS

1—(b) *Six million trillion electrons flow through a 100-watt filament every second at 115 volts—17.1 x 10^{25} electrons per year—weighing about .005 ounce.*

2—(a) *The intensity and duration of lightning strokes are measured and recorded automatically by the "fulchronograph"—developed by Westinghouse engineers.*

3—(c) *Every hour, about 27,000 tons of air are driven through the Wright Field wind tunnel by a 40,000 hp electric motor—designed and built by Westinghouse engineers.*

4—(c) *Iron 99.99% pure, is essential for comparison purposes in spectrography. It is produced in the Westinghouse Research Laboratories by fusing the purest commercial iron obtainable in a high frequency induction furnace, surrounded by an atmosphere of hydrogen gas.*

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LINCOLN

(Continued from page 17)

were closely associated with him. Lincoln always regarded this case as one of the most gratifying triumphs of his career.

This power of Lincoln's to clearly demonstrate his ideas was no mere happenstance. In order to understand fully just what the phrase, "demonstrate" meant, Lincoln, though past forty years of age, began the study of the six books of Euclid. He carried the books with him on the circuit and applied himself with vigor to their mastery. Swett, who traveled the circuit with him says, "I have seen him myself, upon the circuit, with a 'geometry' or an 'astronomy' . . . working out problems and propositions in moments of leisure." Herndon says that Lincoln, after his return from Congress, was a "hard student", especially in mathematics. The maturing of his mind was brought about by his ambition to state a conclusion so logically that the proposition would be proved with mathematical certainty—that it be so well established as to exclude the possibility of doubt or denial.

At the December, 1851, term of the United States Circuit Court, Lincoln had a case of extraordinary interest, one which provided him with a background that he was able to put to good use in later years in the famous "Effie Afton Case." This case was that of the Columbia Insurance Company v. Curtenius et. al. The plaintiff, represented by Lincoln and others, were suing the stockholders of the Peoria Bridge Company for damages suffered by them as insurers of a canal boat and cargo sunk in collision with the pier of the bridge in the channel of the Illinois River. The defendants pleaded that an act of the Illinois legislature authorized them to construct the bridge. Lincoln demurred on the ground that the legislature had no right to authorize the obstruction of a navigable stream. The case turned on the point of the state having the power of obstructing a navigable stream running within its territorial limits. How well this problem of navigation must have brought to the mind of Lincoln his former days as a riverman. The court later decided that the legislature did not have the right to authorize the obstruction of the river and settlement was reached by compromise.

Lincoln's last case of term of the Illinois Supreme Court, February 3rd, 1855, was representing the defendants in error in the case, Edmonds v. Meyers, et. al. This was popularly known as the "Horological Cradle Case." Patent rights to this "horological cradle", a device to relieve mothers of the tedious problems of cradle rocking, intrigued Lincoln and he took full charge of his side of the case in the examination of exhibits and drawings. The scientific and mechanical turn of the case interested him. That he argued his points well may be gathered from the fact that the court's decision, handed down later, reversed the decree of the lower courts previously rendered, in Lincoln's favor.

After the arguments in the case were completed, on his way back to his office in company with a colleague, Lincoln was explaining to him the merits of the invention. His friend ventured to ask Lincoln how the thing was stopped when once placed in motion and Lincoln replied. "There's a rub. I reckon I'll have to answer you as I did the judge who asked the same question. The thing's like some of the glib and interesting talkers you and I know; when it gets to going, it don't know when to stop."

An interesting sidelight on Lincoln's inquiring mind, his engineer's approach to the scientific and mechanical, is brought out by Herndon in describing the occasion on which he, Herndon, brought a copy of Well's *Annual of Scientific Discovery* into their office. Lincoln, who was in the office at the time, took the book, glanced through it, read a little, and then startled Herndon by announcing that he was going out immediately and purchase the entire set. He explained, "I have wanted such a book for years, because I sometimes make experiments and have thoughts about the physical world that I do not know to be true or false. I may, by this book, correct my errors and save time and expense."

This characteristic bent of mind stood him in good stead in the intricate problems presented in the patent cases to be handled by him in association with many other outstanding figures of the nation's bar of the period.

Cyrus McCormick invented his reaper sometime in the summer of 1831. He took out patents on it and the many devices that came in the wake of his original invention. John H. Manny, of Wisconsin, sometime in 1851, produced a similar machine for harvesting grain and he, too, took out letters of patent on his product and began immediate production for sale. His machine became a serious threat to the McCormick product and in November, 1854, McCormick brought suit against Manny in an attempt to stop the further production and sale of Manny's product, which, in many instances, resembled the McCormick machine in construction parts.

Lincoln was one of the distinguished counsel, numbering besides himself, George Harding and Edwin M. Stanton, chosen by Manny to represent him. Lincoln immediately interested himself in the case, especially in the mechanical phases and, while attending the sessions of the United States courts in Chicago during July, 1855, went to Rockford to study the Manny & Company reaper. He also consulted with Mr. P. H. Watson, of Washington, D. C., an outstanding figure in the patent attorney field, on the case.

The case, opening in Cincinnati, September 20th, 1855, before Judge McLean, was destined not to come up to the expectations of Lincoln's hopes of participation for, in spite of his intense preparation, through the machinations of Stanton, Lincoln was forced to withdraw from active participation in the court hearings and remain as purely a consultant. Stanton afterward conceded that, from the knowledge he afterward gained of Lincoln's ability, he undoubtably was as well fitted to handle the case as were either of his two colleagues. It was a very disheartening experience for Lincoln inasmuch as he had planned on the opportunity of matching himself against such men as Reverdy Johnson and Edward M. Dickerson, counsel for McCormick.

(Continued on page 40)

(Continued from page 38)

In December, 1856, in the end of the term of the United States Circuit Court, sitting in Chicago, Lincoln was engaged by the defendants in the case of Durfee & Green v. Sherman & Bay. The complainants, the owners of a patent in connection with a stream dredging machine, were claiming infringement on the part of the defendants and were seeking to restrain them from operating another similar machine.

The struggle between St. Louis and Chicago commercial interests had been a long and bitter one and in May, 1856, an event occurred which brought to Lincoln the opportunity to display his talents which had been denied to him in the McCormick-Manny case. A steamboat struck one of the piers of the Rock Island bridge, was wrecked and burned. A portion of the bridge was also destroyed at the same time. This suit, Hurd et. al. v. Railroad Bridge Company, was more commonly known as the "Effie Afton Case," after the steamer in question.

The *Chicago Daily Democrat* of July 9th, 1857, referred to the fact that the interested parties were endeavoring to have the trial take place in the court of Judge McLean. The case created a great deal of interest in Chicago inasmuch as it was a common belief in that city that the accident was not an accident at all but a deliberate incident on the part of the St. Louis Chamber of Commerce, who felt that the course of western commerce was at stake if the bridge were allowed to stand. The Chicagoans believed that the St. Louis Chamber would go to any length to destroy the bridge. Mr. Norman B. Judd was the attorney for the railroad company and he engaged Lincoln, along with others, to act as counsel for the railroad.

The opponents of the bridge stated their argument in two phases: firstly, that the river, the great waterway for the commerce of the valley, could not legally be obstructed by a bridge; and secondly, that the particular location of this bridge, with reference to the channel of the river, made it a peril to all water craft—that it was an unnecessary obstruction.

The trial commenced in Chicago, September 8th, 1857, and ran through September 24th, with argument and counter argument. Plats and plans were prepared, models exhibited. The newspapers carried running accounts of the case and the arguments of the counsel for both sides. It is very possible that Mr. Lincoln and his colleagues made a visit to Rock Island for a first hand study of the situation as may be gathered from Lincoln's answer to a petitioner for him to speak in Iowa during the time of the trial taking place in Chicago. He says, in part, "I am engaged in a suit in the United States Court at Chicago, in which the Rock Island Bridge Company is a partner. The trial is to commence on the 8th of September, and probably will last two or three weeks. During the trial it is not improbable that all hands will come over and take a look at the bridge, and if it were possible to hit it right, I could then speak at Davenport."

Lincoln answered the first part of his opponent's argument stating, in the main, that "one man had as much right to cross the river as another had to sail up or down it." In answer to the second part of his opponent's argument, Lincoln succeeded in showing, with a careful explanation of the current of the Mississippi River at the point where the bridge crossed, that the pilot, if he were as familiar with the river as might reasonably have been expected, could have prevented the accident from occurring. His argument in this instance was marked by perfect candor but was full of nice mathematical calculations, clearly put. Lincoln had learned the meaning of the word "demonstrate".

Much has been written about Lincoln's familiarity with the Bible, a knowledge that could only connote a very close study of the various books. This knowledge was used by Lincoln to illustrate his arguments and point a moral when he so chose. A little known side of Lincoln is his short-lived career as a lecturer. In February, 1859, Lincoln was elected to honorary membership in Phi Alpha Society of Illinois College at Jacksonville, Illinois. He presented his first lecture, February 11th, under the sponsorship of the Society, at the Congregational Church in Jacksonville. His discourse was entitled, "Discoveries and Inventions," a rather dry discussion, leaning heavily on the Bible and the allusions, therein, to the development of mankind through their intellectual advancement. From his opening sentence, "All creation is a mine, and every man a miner," through the natural phenomena of the animals of the earth to man, his inventions and discoveries primarily to improve his condition, Lincoln led his audience. He ended on a note of wonderment relating to the fact that the advantageous use of steam power should be so recent a discovery in spite of the fact that the power of steam, translated into a very ingenious toy at Alexandria, in Egypt, was known by the ancients.

Lincoln must have felt encouraged by the reception of his lecture, for on February 21st, he again delivered it at Myer's Hall in Springfield. This time he had his law partner, Herndon, in the audience as a friendly critic and it was Herndon's opinion that Lincoln was not of the material that lecturers are made. At least Lincoln never attempted to carry this avocation any further after these trial attempts.

This characteristic of Lincoln's, his marked interest in things of a mechanical nature, was retained by him even in the White House. The coming war clouds, the need for armament, opened a new field for inventors. Washington was overrun with men having guns to be tested, approved, and used by the Northern soldiery.

A clerk in the Ordnance Department, during the war days in Washington, tells of meeting Lincoln in the hall of the department and receiving from him an invitation to come and test a new gun. His story had a refreshingly intimate touch as he relates that the President, "then pacing off a distance of about eighty or one hundred feet . . . raised the gun to level, took quick aim, and drove a round of seven shots in quick succession, the bullets shooting all around the target like a Gatling gun and one striking near the center." This trial did not suit the President, however, and his com-

panion reports that he remarked that, "I can make this gun shoot better," and whittled a wooden sight which he affixed over the sight of the carbine and proceeded to do better.

Such memoranda as the one to General Ripley, Chief of Ordnance. "Will General Ripley please consider whether this Musket-shell would be a valuable missile in battle?", or the one to Captain, later Admiral, Dahlgren, "You have seen Mr. Blunt's new gun —What do you think of it? Would the government do well to purchase some of them? Should they be of the size of the one exhibited, or of different sizes?" are but a few of the references, noted in Dahlgren's diary that record Lincoln's deep interest in ordnance, ammunition, and related matters. This close contact with Dahlgren created a deep friendship between him and the President.

Lincoln had other interests in the field of mechanics as witnessed by his memorandum to Dahlgren, "Captain Lavender wishes to show you a contrivance of his for discovering, and aiding to remove, under-water obstructions to vessels." When John Ericsson approached the senators and congressmen with his plans for an ironclad vessel for war use he was rebuffed in no uncertain terms. He finally was able to make contact with President Lincoln who listened to his ideas, studied his models, encouraged him and was instrumental in having the navy accept the "Monitor" for the North. He followed the building of the craft with the deepest of interest.

President Lincoln interested himself in the experiments with the use of balloons in observation work in connection with the army. He was one of the first persons in the country to receive telegraphic messages from a balloon sent up to make observations on the enemy's works. His encouragement of these endeavors brought about the full acceptance of this plan and the Smithsonian Institution issued a statement that "from experiments made here for the first time, it is conclusively proved that telegrams can be sent with ease between balloon and the quarters of the commanding officer."

Harking back to his days as a congressman in Washington is a memorandum from the President to the Secretaries of War and Navy, in February, 1863, following the great successes of the Confederates at Fredericksburg, urging the appointment of representatives to test the use of certain incendiaries as adaptable for military use.

In his Annual Message to Congress in December, 1863, President Lincoln urged upon Congress the consideration of an international telegraph across the Atlantic. This in addition to coastwise cable service. He referred to arrangements that had been made by the government with the Czar of the Russias for the construction of a telegraph line from the Pacific Coast, through the Czar's territory, to connect with European systems. He was in close contact with Cyrus W. Field, who was the chief exponent of the Trans-Atlantic cables.

Abraham Lincoln did not consider himself to be an authority on military matters but throughout his term he showed a practical wisdom in military affairs. His suggestions to the military authorities showed a native shrewdness, a practical sagacity that is the essence of military strategy. He instinctively grasped the salient features of the plans under consideration and could give them proper values. He, in theory, carried out the duties of the modern High Command in the survey of the war as a whole. The recognition of the fact that he had the use of superior naval strength, and made the most of it; that in dealing with a raw army, he fitted political considerations in with a strategic deployment of men: his insistence, throughout the war, that constantly maintained pressure be kept on the enemy forces: and his recognition that the main body of the enemy, the principal objective, should always be kept in true perspective, are those functions that would come within the province of the modern High Command.

The widespread belief that Lincoln, as a youth, a country bumpkin, developed overnight into his character as a statesman; the tales of dire poverty, told out of all perspective as to his friends and neighbors, had their value in political advantages at the time, but the actual facts of the case point up an entirely different picture with the realization of Lincoln's possession of an alert mind. Knowledge, gained through patient persistence, caused Abraham Lincoln to rise, through his own efforts, from obscurity to immortality.

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LEWIS

(Continued from page 19)

stances. From the younger men working with him at the time, he recommended George Noble Carman, then Principal of Morgan Park Academy and a member of the English department of the University of Chicago, to head the new institution. These two men agreed perfectly as to the plan of study to be carried on, the trustees acquiesced, and Lewis Institute was incorporated to offer a four-year high school course in technical subjects and liberal arts, and an additional two years of college work in arts and engineering. While the actual term "junior college" is not used in this specific grant, Lewis really became the first junior college to be established in the United States. In that first year, 1896-97, a day, evening, and a summer session were conducted, and if newspaper publicity is an indication of educational value to the public, Lewis certainly filled a long felt need. One of the first of the experimental schools was on its way, and no one was even hired on the faculty who was not willing to "go along" with new ideas in education.

On the memorable morning that the Director and the Dean came up Madison street actually to open the doors of the Institute, two little boys were sitting on the curb-stone waiting for the great event. Both of them are now well known in the educational world; one of them, the mathematical wonder, George Birkhoff, was said by many to have been the greatest mathematician in the world at the time of his death. I should not be so rash as to say that the actual training George received during his high school and college years at Lewis made him what he was, but he always insisted that the encouragement he received there to step out of the beaten paths and to develop his own mathematical ideas started him on his way.

The Institute, in those days, instead of offering formal examinations to new students, held an "opening week", a classification period such as we know today. I have never heard of the plan being used before it was tried out here, but it may have been in existence elsewhere. The problem of the individual was always strongly stressed, for the Institute began by establishing an "elective" system in the high school years in the hope of developing self expression. The three "R's" and the classical background were emphasized, but the student had a chance to choose a few subjects to complete his program and was delighted with his liberty, while the die-hards in the city schools shook their heads in horror at the departure from the cut and dried formulas of the day. Many years later, at a banquet of honor given to Director Carman, much was said as to the time and thought he had given to the development of the individual, and the original Dean of the Institute, Professor Edwin H. Lewis, whose writings were generally so profound that only a few could understand them, penned these lines "To Our Chief":

Carman likes to make a man, and
now you'll all agree
He did his level best to make a man
of you and me.
Carman likes 'em different, and, too,
we'll all agree
I ain't no copy of you, my dear, you
ain't no copy of me.
For one by one he studied us, he
studied you and me,
And always he respected individuality.
A great expert in persons and a maker of them, too—
That's what the dear old boy has
been to all he ever knew.

In the second year of its existence the Institute was host to a group of men from all over this western section of the country. Led by Dr. Harper, with Director Carman and Dean Greeson of the Institute, and Dr. Angell of Michigan, these men were working on establishing standards in the college and high school fields. The new Lewis was the last word in building and equipment, and the group were anxious to study new physical developments as well as to work on standards, so they filled our Auditorium, and at those meetings the accrediting association known as the North Central Association of High Schools and Colleges was formed. Lewis always occupied a place on its list.

In 1901 the trustees began granting degrees to mechanical engineers and, in the years that followed, this department was extended to include other fields of engineering. In 1903 the building on Damen avenue was erected to increase the facilities of the engineering department. John A. Roche, former Mayor of Chicago and the first President of our Board of Trustees, who was devoted to the interests of Lewis, promoted the undertaking. The bronze tablet that was erected in this building to the memory of Mr. Roche

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CONTRIBUTORS

(Continued from page 3)

Dr. McDonald is a graduate of McGill University and received the master's and doctor's degrees in physical chemistry from Carnegie Institute of Technology. He joined the Illinois Tech Department of Chemistry in 1939.

Robert C. Peterson is Associate Professor of Safety Engineering. His professional record is reported in the Contributors' column of the October, 1946, issue.

K. Nagaraja Rao was born in Bangalore, in the south of India. He studied at Mysore University, where he received the degree of M.Sc. in Chemistry. He has taught chemistry at Central College, Bangalore. Mr. Rao is a graduate student in the Department of Chemical Engineering at IIT, holding a fellowship sponsored by the government of Mysore.

Herbert A. Simon is Associate Professor of Political Science and Chairman of the Department of Political and Social Science in Illinois Institute of Technology. He is a consultant to the International City Managers' Association, and the U. S. Bureau of the Budget. Before coming to the Institute in 1942, he was director of administrative measurement studies for the Bureau of Public Administration, University of California. He took his doctorate degree at the University of Chicago. He has published a number of books and articles on public administration, local government, and the economic and administrative aspects of city planning.

The Cover Picture is by Norman A. Bartley of the photographic staff of the Armour Research Foundation. It shows equipment in the organic chemical laboratory of the Foundation.

was the work of instructors and students then in attendance; the sculpturing being the work of Mr. E. S. Hinton, an instructor in architectural sculpture in the evening session; the casting was done under the supervision of Mr. C. E. Hoyt in charge of the foundry work, who made it possible for the piece to be cast in our own foundry.

Home economics courses were opened with the Institute, and since this was a comparatively new field in this section of the country, they grew rapidly in attendance until, with the demand for college graduates as home economics teachers, the Institute took a step forward and granted that degree to its students. That was in 1912. This department ran the lunchroom in those early days, another novel feature found in no other high school in Chicago. Well do I remember the menus and the cost of the food, and often do I sigh for those good old days when we were served a delicious hot dish, soup or milk, and dessert, each item costing five cents. And then if we ate fifteen cents worth, two slices of bread and butter were added to our trays, and we ate off real china and had linen napkins. I'm not dreaming, either.

Some few years ago the Home Economics section of the Bureau of Education at Washington, studying the history of this department, found that the course generally known as "Household Management" or later as "The House; Its Plan, Selection, and Care" was first evolved and taught at Lewis in the early 1900's.

The opening paragraph in the section of the Lewis will that pertains to the founding of the Institute says "It has long been my desire to, in some manner, provide for and assist those in need of an education, and who are so circumstanced in life as to be unable without aid and assistance to obtain the instruction and gain access to books and papers of art and science that their future advancement in life requires". At the time the Institute opened it was not possible to comply with this desire, because so few of "those so circumstanced" cared to have more formal education than was offered in the grade schools, and inasmuch as Lewis was built in the heart of what was then one of the fashionable and well-to-do districts in the city, it started its career with the easily acquired title of a "fashionable prep-school". This situation existed until as late as 1908, when another general shift in population took place, and a more mature type of student sought instruction there, a type that was employed at least part-time, and was unable financially to attend one of the larger universities. Then, at last, the fundamental desire of the founder came to be realized.

In 1909, through the generosity of LaVerne Noyes, one of our trustees, a co-operative course was inaugurated for boys of high school age who also served as apprentices in industry. The tuition of the boys was paid by Mr. Noyes when they were not working, and splendid co-operation was given to the course by many firms in the city. The decrease in the attendance of boys of high school age and the requirements of industry during the early years of World War I made it necessary to close the co-operative course.

In 1913 a contract was signed with the Portland Cement Association to establish the Structural Materials Laboratory at the Institute for purposes of research and for the training of men competent to assist in concrete construction. This laboratory was maintained until 1926 when the Association moved into its own building. I venture to say that no college ever had more pleasant and co-operative associates than the men and women who worked with us under the direction of Mr. Duff Abrams.

During World War I, Lewis was the headquarters of the educational work of the Sixth Corps Area. A most successful training school for ground mechanics was maintained there, and rehabilitation work for veterans was carried on for about six years after the war. Letters in our files that came to Director Carman from the War Department in Washington indicate that the plan inaugurated at Lewis served as a model in many colleges throughout the country.

In 1917, because of a growing demand for more college work, the general degree of Bachelor of Science was added to the Engineering and Home Economics degrees. Then the evening session courses were offered on the college level, the Academy was discontinued, and the Institute emerged from World War I as a four-year college on the lists of the North Central Association.

Probably the most outstanding feature of Lewis Institute was the administration under the leadership of Director Carman, who was generally acclaimed one of the leading educators of his day, and who remained at the helm for forty years. It was his custom to register and consult with each student personally in the day school, and with as many as he could in the evening school. He lived for the Institute, and after the death of his wife in 1916 he made it his day and night work, seven days a week, and he had no other interests. It is said that he did the most outstanding piece of personnel work that has ever been accomplished in an American college. The tenure of the faculty who served under him was long, for the men and women who taught at Lewis believed in the purpose of the school and were willing to devote their lives to teaching at the Institute. I have never happened to hear of a school where faculty and students worked together with so little appreciable friction and such full co-operation. As one student put it—"the factor beyond price in this educational experience at Lewis is the intimate personal contact with the faculty." This situation existed because of the Director's clear understanding of human nature and its needs.

That the Institute served the purpose for which it was founded can scarcely be doubted. During the first ten years of its existence, the attendance in the day and evening sessions amounted to about 10,000 individuals. From that time on, as the desire for education grew among young people, the numbers mounted rapidly, and in 1940 more than 100,000 students had attended the Institute from one term to twenty years—a record made by a student in the evening session. This count was actually made by me over a space of time and was not figured by a hit and miss method.

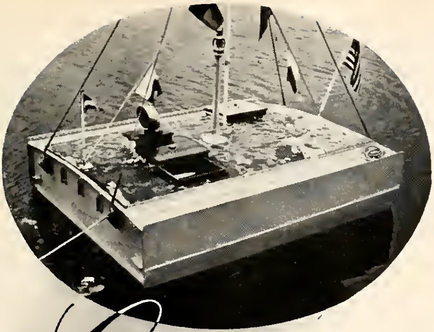
(Continued on page 46)

(Continued from page 44)

I regret that I haven't enough space to enumerate the Lewis students who have gone out to fame and fortune, but alas! the editor said 3000 words. In looking back over the years I spent at Lewis as a student, as secretary of the Alumni Association, as an instructor, and as a member of the administrative staff, and counting the value of the Institute to the community as I saw it from day to day, I can easily understand the statement made by the president of one of the eastern educational foundations when he wrote of Lewis "that in all their studies of the schools and colleges in our land, they had found none that had accomplished so much with so little endowment." I should like to quote to you from a speech of Director Carman's concerning this accomplishment, the largest part of which was of his own making. "A great opportunity was presented to us. We have done our best and the general public have been duly appreciative. May we not be content with this? May we not have something of the serenity felt by Franklin, when, as he looked back over his life as a whole, he asked himself whether, if the opportunity were given him to try it all over again, it would be worth while? You remember his conclusion, 'That felicity, when I reflected on it, has induced me sometimes to say that were it offered to my choice, I should have no objection to a repetition of the same life from its beginning, only asking the advantages authors have in a second edition to correct some faults of the first'."

I cannot conclude without this observation—I have never known anyone who had a real and honorable part in this educational venture known as Lewis Institute, either as a student or as a member of the faculty or of the basement staff who did not gain something fine from the contact, or who did not contribute something in the way of loyalty or devotion that was beyond price. In a recent edition of the ENGINEER there is a letter from a Lewis alumnus who says, "Your letter brought to my mind the great debt I owe to Lewis, a debt constantly built up during the four years I attended the Institution. It is a feeling of gratitude toward a school that gave help in all the ways it could and asked for nothing in return of its students or alumni". Perhaps that alumnus does not realize that his letter is the best return on an investment that a college could have. That feeling of gratitude, I know, is in the hearts of thousands of Lewis students.

Editor's Note: Illinois Institute of Technology was formed by a consolidation of Armour Institute of Technology and Lewis Institute in June, 1940.



Cinderella

TAKES A CHINESE HONEYMOON

• The Cinderella of Chesapeake Bay is a queer looking craft. She has no bow, no stern, no engine, no crew. Never weighs anchor to make a voyage. But she *has* a purpose, and has served it well.

Largely because of her, a new fleet of ocean-going passenger ships will have superstructures built of *aluminum*. It reduces weight at the most important place—"topside".

This is a dream come true for Alcoa engineers. Eleven years ago they built this odd-shaped aluminum test hull and anchored it in Chesapeake Bay. Together with marine engineers and naval architects, they watched to see the effect salt water had on aluminum; whether it would prove seaworthy. And it did!

But there were other problems—for instance, stresses topside, set up by the weaving and pounding that a ship takes at sea. By building and testing a model, Alcoa engineers found that the use of aluminum in the superstructure greatly reduced the stresses. They likewise conferred on plans and recommended materials.

So the ships were built. They are in the water now being outfitted for their maiden voyages to China—thanks to Cinderella and the "imagineers" who dreamed of aluminum ships and then engineered them into the water.

Doesn't a company that pursues an ideal with such intensity stir your imagination? It's fun to work with men of vision. Ideas click when men with imagination plus engineering work with this versatile metal, aluminum, and with the greatest fund of aluminum knowledge in the world . . . Alcoa's. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN **ALUMINUM**

RE-DEVELOPMENT

(Continued from page 24)

planned as to eliminate the causes that brought about the original blight—causes that would otherwise insure its speedy recurrence. A large enough area is of course an essential, but it is by no means the only requisite. Urban redevelopment will succeed only if it can bring into the centers of our cities the important advantages enjoyed by the suburbanite, combined with the equally important advantages of a central location. Families will not return to the cities unless they are assured of the same pleasant surroundings, good schools, and community facilities that they can have in outlying districts.

This means that the redevelopment project, whether private or public, must reflect the best thinking of modern city planners for community design. In the case of public projects, the public agencies themselves can assume responsibility for this planning. In the case of private projects, some measure of community control must be exercised so that the development will really achieve a "public purpose" and so that it will be properly coordinated with the overall city plan.

Proper design of community areas usually requires substantial modification of the existing street plan, and often the relocation of railroads and other utilities. Hence, not only must existing structures in the area be largely written off, but existing streets, sewers, and water mains as well. Since the existing utilities are usually found to be inadequate and badly deteriorated, the economic loss because of relocation is not too serious. Moreover, the installation of new utilities is a cost that must also be borne by new subdivisions in outlying districts.

Satisfactory results can be expected from redevelopment only if the project locations are selected and the projects designed with proper relation to the rest of the city. The type of redevelopment that should be undertaken will depend on the amounts and kinds of housing that exist in or are planned for other parts of the city. Thought must also be given to location of the project in relation to places of work and commercial areas. Logically, then, the plan for the individual redevelopment project should be based on a comprehensive housing plan and a land use plan for the whole city, and even, in the case of centers like Chicago, for the whole metropolitan area. Lack of comprehensive plans may leave piecemeal redevelopment as the only alternative course of action.

Most redevelopment laws, including those of Illinois, provide that the design of private redevelopment projects must receive approval from a public authority—the city planning agency or a redevelopment commission, or both. Such a requirement works, of course, to the advantage of both the community and the redevelopment corporation—to the former in providing well-planned housing and community facilities, to the latter in protecting the investment from the threat of future blight.

Relocating The Population

At this point a further problem—and a very serious one—intrudes itself. Provision must be made for the housing of the population presently living in the blighted area. To be sure, the redevelopment would usually house as many or almost as many persons as lived in the area before reconstruction. The number provided for would depend upon the amount of vacant land and commercial property in the exisiting area, and the population density contemplated in the project design. It should be pointed out that proper community design does not preclude reasonably high population densities. The large Metropolitan Life Insurance Company project, in New York's lower East side, will house about 30,000 people in an area where 27,000 lived in 1920, and only 11,000 in 1943.

The problem, then, is not really one of numbers, but of economics. The inhabitants of the blighted areas are drawn from the lowest income strata of the city. They are not able to pay rents that would finance proper housing, even when the high costs of site acquisition are left out of account. These groups have traditionally occupied second-hand housing, left behind by more prosperous families who move into new homes. Even the substantial subsidies provided in federal housing projects did not permit rents low enough for the poorer families who had previously lived in the slum areas. For this reason, many slum clearance laws, and the Illinois redevelopment law as well, provide that a project may not be undertaken unless it is found that there will be adequate housing elsewhere for the displaced groups.

In Chicago and other cities the problem is further complicated by questions of race. Negroes are prevented from moving to other areas by legal and social restrictions that have produced, in Chicago, a virtual "ghetto." The Negro community, having far more than its share of low income families, will inevitably be seriously affected by large-scale redevelopment plans unless special consideration is given to its needs.

The problem of displacement, being just one facet of the problem of poverty, has no easy or single solution. Some of the present occupants of slum housing will be able to afford the rents of the redevelopment project. Others will find second-hand housing vacated by families moving into the new projects or other new housing. Provision must be made for many in subsidized public housing. For the rest, a solution can be expected only if there is a continued general increase in levels of real income.

Some other problems of relocation can only be mentioned here. One is the need to educate the re-housed slum dweller so that he will not abuse his new surroundings. In particular, there must be developed in him such a pride in his community that he will not tolerate his own or his neighbor's poor housekeeping, exhibited in such forms as garbage-strewn alleys. That such education is possible has been demonstrated in many housing projects, public and private. That such education is needed—and not only for low-income groups and slum dwellers—is amply demonstrated by Chicago's alleys and paper-littered parks.

Still another problem, related to the race question, is that of uprooting individuals from communities in which they have lived for many years, and to which they are tied by social, religious, national, and other associations. Particularly in areas occupied by first-generation immigrants speaking a foreign language, this matter cannot be treated lightly. It explains why such groups so often bitterly resist "progress" that would destroy the associations which mean so much to them.

Redevelopment In Chicago

It should be clear from the previous discussion that redevelopment is no simple cure-all. On the other hand, whatever the difficulties, it represents the only tangible hope for curing the rot that has infected the centers of our cities and forced to the suburbs many of their residents who prefer long commuting hours to the unpleasant surroundings of the central city.

Chicago is now witnessing a courageous attack on blight in its South Side by institutions which are located there, and which have decided to fight the battle at their present locations, rather than surrender and move elsewhere. Illinois Institute of Technology and Michael Reese Hospital are taking the lead in this battle. They have decided that their investments in their present sites justify a determined attempt to remodel their surroundings rather than to move to other locations where, a generation later, they may be caught again in the cycle of deterioration. The area selected for reconstruction is bounded, roughly, by Twelfth Street on the north, Forty-Seventh Street on the south, the Pennsylvania Railroad tracks on the west, and the lake on the east. Each institution has taken primary responsibility for the area immediately adjoining its own plant, but success for the project will require the enthusiastic cooperation of other institutions located in the community, as well as the Chicago Housing Authority, Planning Commission, and Redevelopment Commission. Steps toward securing community cooperation have been taken with the recent formation of the South Side Development Association.

The story of this project is too long to be told here, but the recent adoption, in Illinois, of redevelopmnt legislation makes the prospect more hopeful than it has ever been before. Success in this project will represent one of the most important achievements in city planning and community development that the United States has witnessed.[1]

[1] An excellent account of the project will be found in the September, 1946, issue of *The Architectural Forum*.

MEN

(Continued from page 25)

chemical engineering, plastics, dyes and intermediates. oil technology, and mining and metallurgy; their laboratories contain quite modern equipment. At Cawnpore there is the Institute of Sugar Technology and Delhi has a good polytechnic. Mysore and Madras have engineering colleges and occupational institutes. The Indian Institute of Science, where the Nobel Laureate, Sir C. V. Raman, is working. the Board of Industrial and Scientific Research, the Tata School of Fundamental Research, the Imperial Council of Agricultural Research, and the Fuel Research Institute are institutions of higher learning and research and have made notable contributions to knowledge, both fundamental and applied. Arrangements for the starting of the National Physical, Chemical, and Metallurgical Laboratories are fairly complete.

With all these, it has to be said that the educational needs of the country are not fully met. India is a rich vast continent containing a teeming 400 millions and well-planned technical and general educational facilties must be offered on a much larger scale than are available now. before the country could be put on a pace of vigorous industrialization and progress. The need has been well realized and a scheme of education, worked out by the Educational Adviser to the Government of India. Sir John Sargent, which would cost about 300 crores of rupees when in full operation, is before the nation. It envisages the raising of literacy to a high percentage and offers increased facilties for technical training not only in the high school stage, but also at higher levels. Some of us who are in this country now receiving training in various institutions will probably be asked to fill posts in such schools. The practical type of instruction which we are having now in this country will be of great value to us when we are back in our country.

The actual scheme of education in India is as follows. The elementary school is the place where the pupils pick up the fundamentals. the 3 R's. They then go to the "middle schools." which in a rough way correspond to the junior high schools of America. After four years of stay here, the pupils enter the high school. At this stage they take up either science and mathematics or the humanities as the basis of their future specialization. Only those who have studied mathematics and science are eligible to enter the university or branch off to the technical high school. The university course comprises two stages. The first stage which runs for two years is called the "intermediate course;" the subsequent four years comprise the actual degree course in the particular subject of the pupil's choice. For the engineering degrees, therefore, the students will have to successfully go through six years of university training. Degrees are, however, conferred only after the student has completed six months of practical training in his field, in a factory or office of recognized standing. The engineering curricula are all modeled after those of foreign universities but emphasis is placed on local conditions and local needs. The study of Indian economics and of technical drawing forms part of an engineer's course. Chemical engineering is, however, only a young profession in India and it is being offered only in three or four universities. In recent times, increased attention is being paid to this and more universities will offer courses in chemical engineering.

"Self is a subject inexhaustible;" one knows no end when one begins to talk or write of himself or his country. One point. however, is important to recognize. Our world is in the throes of a vast change. With two wars in a single generation people have lost faith in the goodness of men. They have begun to doubt if people can come together at all and build a good world for all to live in. We hope that this unique opportunity provided us of coming over to this country will help us know each other better and contribute in our own small way towards the greater world understanding and cooperation. Come. therefore; stop us: and talk to us. We shall know each other better.

TORQUEMETER

(Continued from page 22)

automobile engine delivering thirty horsepower at three thousand RPM. Oscillograms were obtained of instantaneous or dynamic engine characteristic torque pulsations under normal and abnormal conditions. For example, the results of cutting out one cylinder is shown in the torque oscillogram, Fig. 2. The instrument proved to be very insensitive to mechanical vibration and electrical noise pickup.

These tests on stationary and rotating shafts have provided definite evidence of the soundness of the underlying theory and of the practicality of constructing a compact, accurate, and reliable torquemeter, operating on this principle. The capability of the instrument to respond properly to torsional pulsations and transients has been clearly demonstrated.

Present And Future Development

The results of tests performed on the present experimental model torquemeter indicate that the unit possesses a high degree of mechanical, electrical, and thermal stability. However, the need for more complete fundamental data of both qualitative and quantitative nature is recognized. The immediate program of research includes the following fields of investigation:

1. Tests on various methods of spraying, plating or bonding optimum torque-sensitive surface films or materials onto practical engine power shaft surfaces.
2. Exploration and extension of the temperature range within which the torquemeter can be made operative.
3. Construction of a pickup unit made in two halves so that it will encompass a shaft provided there is a short section available. This will avoid the necessity of slipping the pickup unit over the end of the shaft as is done with the present model.
4. Design and construction of an electric unit having much smaller physical dimensions, simplified electrical circuit and improved performance.

Conclusion

Tests have conclusively verified the theoretical predictions and demonstrated the practicality of constructing a compact, accurate, and reliable torquemeter operating on this principle, which can provide oscillographic indication of torque pulsations or transient torsional loads and stresses. The fields of usefulness for such a device are numerous. For example, it has been suggested by airlines operations engineers that flight monitoring (by the flight engineer) of engine torque pulsations, cylinder by cylinder, would be a valuable aid in checking engine operation and diagnosing maintenance requirements. For this type of measurement, and for measurement of torsional vibration, an instrument capable of accurate dynamic response and indication is necessary. Such an instrument would also have many applications connected with research and testing of mechanical power transmission systems of all kinds, both in the laboratory and in the field.

Recognizing that the torque-responsive or pickup unit is of very great importance in torquemeter design, and that the same unit must be readily and widely applicable to a great number of power transmission devices without requiring appreciable modification of the latter, the Armour Research Foundation is pleased to report progress on this entirely new and different form of torque responsive device.

SCHOOLMASTER

(Continued from page 28)

to the comfort of all of us. Do we take ordinary precautions against injury to life and property by fire or other accident? Let's play it safe, and ask the other fellow to do so. The student can do more in this matter than the faculty or the administration. The Institute is for men and women of ability and studious habits. Our students are a good bunch. The rigor of our requirements for admission, for remaining at the Institute, and for graduation is one of our most important assets. Do we all take maximum advantage of the many opportunities for activities outside the classroom—in the fraternities and scientific societies, in religious and other cultural groups? What about propaganda to this end? Do we have an amused tolerance for the liberal arts schools, with their less demanding programs? Let's guard against the smug satisfaction that says "Us engineers don't need no English." (Dean Peebles wrote a good article on that text years ago.) On the other hand, have we a feeling of inferiority when we think of our liberal arts friends, forgetting that a well-trained engineer is and must be an educated man and a cultured citizen, whose education continues as long as he lives?

Let's propagate the idea that we have an outstanding opportunity, that we are doing well, that in many respects we can do better. If that is preaching, propaganda, missionary work, we need not be ashamed of it.

SAFETY

(Continued from page 26)

in the matter of reaction time should result in substantial reduction in number and severity of accidents. It may be argued that annual "refresher" tests and instructions are desirable.

Nothing in this brief discussion is intended to imply that the mere giving of tests will improve a driver's reaction time. The tests indicate and record. They are useful, but they do not in themselves produce safe drivers.

Obviously, the problem of highway safety involves many factors besides those discussed here. On the engineering side, great progress has been made in the improvement of road surface, in traffic control signals, in the arrangement of grade intersections, in superhighways, in effective traffic distribution, in four-wheel brakes, in windshield wipers and defrosters, and in many other things. In the actual prevention of collisions, the problem of decelerating and stopping a vehicle involves tire conditions, the weather, the condition of the brakes, the density of traffic, and other matters. Nevertheless, intelligent understanding of the reaction time factor by the driver would prevent many accidents. As an elementary illustration, with low visibility the rate of travel would be reduced. To put the matter broadly, the driver would have the same kind of knowledge of his own characteristics as he has of the capabilities of his car. Both are necessary.

Electronics in Railroading

Electronic science has become indispensable to modern railroading and will undoubtedly play a leading part in the further progress of the transportation art, C. D. Young, Vice-President in charge of Purchases, Stores, and Insurance, Pennsylvania Railroad, recently told the faculty and students of Mount Union College at Alliance, Ohio.

Mr. Young maintained that signal apparatus in locomtive cabs "is without doubt the greatest advance that has ever been made in railroad signaling and one of the most important contributions to railroad safety."

"Cab signals," he said, "involve the use of electronic apparatus, located in the engine cab, which picks up by induction—that is, across an air space—impulses from electric currents in the rails. It then steps up these impulses so that they operate two signal panels located inside the cab. One panel is before the eyes of the engineman and the other faces the fireman. On these panels, combinations of electric bulbs reproduce, within the cab, the indications of the wayside signals. In that manner the safe and uninterrupted operation of the train is rendered independent of fog, snow, rain, or other conditions affecting outside visibility."

The Induction Train Telephone

Another electronic principle developed by the railroad is the induction train telephone, he pointed out, adding:

"This is a device which permits telephone communication between one moving train and another, between moving trains and wayside towers, and between the ends of trains regardless of their length or track curvatures. The induction train telephone is neither radio nor wire telephony. It utilizes features of both methods of communication that are desirable in railroad operation and eliminates other undesirable features.

"Instead of depending upon radio waves, broadcast into space in all directions, and capable of being picked up by all similarly tuned receiving sets within range, we proceeded to devise a scheme which would confine the transmission paths to railroad property. We wanted to avoid the need for assignment of wave lengths and to prevent conflict with radio reception."

To accomplish this, Mr. Young explained, the Pennsylvania uses the track rails as transmission paths, supplemented by wires strung on poles erected along the tracks. Installed in the engine cab are suitable electronic and other apparatus, together with a telephone receiver and transmitter.

"When an operator in a wayside tower wants to talk to an engineman in his cab, he continued, the vibrations of the operator's voice in his transmitter sends out minute electrical impulses over the transmission paths and these impulses are picked up inductively by the electronic devices in the cab, across the air spaces between the cab and the wayside wires or track. The impulses are then magnified millions of times in volume and converted into audible sound in the engineman's receiver. When the engineman replies, a reverse chain of events takes place.

Connects Engineman And Conductor

"When the caboose of a long freight train is similarly equipped, the engineman at the front of the train and the conductor in the cabin car at the rear end can converse with each other at will. Either of them can also talk to the crews of other trains within the territory equipped for this form of communication, and with the operators at wayside towers."

He disclosed that in 1944 the Pennsylvania started to apply the train telephone system to two exceedingly busy mainline divisions, the Middle Division, extending from Harrisburg, Pa., to Altoona, Pa., and the Pittsburgh Division, from Altoona to Pittsburgh, a total distance of 245 miles, with four running tracks the entire distance, in addition to numerous sidings.

"The installation is at present over 95 per cent completed and is largely in use," he reported. "The project involves equipping for induction telephone intercommunication some 300 passenger and freight locomotives, 90 freight train cabin cars, 13 strategically located wayside towers, and all four main tracks, totaling 980 track-miles. We anticipate that everything will be finished before the end of the present year."

NAVY DEPARTMENT

The Civil Engineer Corps of the United States Navy will shortly hold examinations to commission 75 qualified graduate engineers, 22 to 30 years old, as Lieutenant (junior grade) in the Civil Engineer Corps of the Navy.

Eligible are native or naturalized citizens with three years engineering experience, two of them subsequent to receipt of their degree, or the military equivalent. Applicants must be physically, mentally, morally and professionally fit. Applications may be obtained and filed at nearest Offices of Naval Officer Procurement.

Exams, to be held on two separate days, will consist of a $2\frac{1}{2}$ hour general engineering test, an oral exam, and a 90-minute test on engineering problems. None of the exams will require special preparation as questions will test general engineering knowledge of the applicant.

An important consideration in these examinations will be the candidate's experience. Exams will not be aimed at the man fresh from textbooks, capable of extensive quotations. Preferable is the man with experience and vision, who has developed ability to reason, and initiative to solve problems set before him.

NEW PERMANENT MAGNET MATERIALS

Five new permanent magnet materials . . . cunico, cunife, vectolite, alnico 12, and silmanal . . . were announced early this year by the General Electric Company. These new materials have many applications in the manufacture of aircraft instruments as well as other industrial uses where small lightweight magnets formed in intricate shapes are required.

CUNICO is an alloy of copper, nickel and cobalt. Cunico magnets are made from rod, strip or wire stock, and are furnished only in their final shapes because they are age-hardened in the manufacturing process. Cunico is malleable, ductile and machinable, permitting the manufacture of small magnet screws from this material by ordinary screw machine methods, and the punching of intricate magnet shapes.

CUNIFE is a copper-nickel-iron alloy which has all the physical properties of cunico. However, cunife differs from cunico in that it has directional properties and must be magnetized only along the direction in which the material has been worked, to obtain highest magnetic quality. Cunife magnets are made from wire stock in round, square or rectangular form. In addition, cunife wire can be flattened to make thin, narrow shapes. A wide variety of magnet designs can be obtained by forming, drawing, punching or machining cunife to shape.

VECTOLITE is the first nonmetallic, nonconducting magnet material ever made. It is a hardened, sintered combination of iron rust and copper oxides mixed when still in powder form. Vectolite magnets are extremely light, being nonmetallic, and their nonconductive properties prevent electrical losses caused by conduction of current. In addition, they have a high coercive force, or resistance to demagnetizing forces.

ALNICO 12 is made up of aluminum, nickel, cobalt, iron and titanium. Magnets made from this material can be used in such applications as in tachometer generators and electronic devices.

SILMANAL has a high intrinsic coercive force. Magnets made from this material are very useful in instruments where service in strong electrical fields is required. Silmanal which is ductile and malleable can be punched, machined, rolled, or ground. Because of its ductility, silmanal can be made in rod, strip or wire form.

STAR GAZER

Scientists of the California Institute of Technology are back at work completing the world's largest telescope, the 200-inch giant installed atop Mt. Palomar in California. Progress on the instrument, which is expected to enable astronomers to peer one billion light years into space, was interrupted by the war.

Resumption of work on the telescope recalls many of the ticklish engineering problems involved in building the huge 500-ton mounting that will support the 200-inch mirror and optical system. Toughest of these, perhaps, was the job of fabricating and machining the 317,000-pound horseshoe bearing on which the telescope will ride on its tour of the skies.

The bearing, along with the rest of the mounting, was built at the Westinghouse works in South Philadelphia, which was assigned the job because it was one of the few plants in the world with space and equipment large enough to handle it. But the task of machining the steel surface of the bearing to the specified tolerances required a boring mill larger than any heretofore used. So the bearing was shipped via three freight cars to the East Pittsburgh plant, where a boring mill—already one of the world's largest—was enlarged to a diameter of forty-four feet. Then began the work of paring off the steel until the bearing was within five one-thousandths of an inch of a perfect circle.

Almost immediately engineers ran into trouble from sun rays streaming through shop windows. Every afternoon at four o'clock the bearing began to swell from the sun's heat, sometimes as much as thirteen thousands of an inch. At night it contracted. After several partially successful efforts to solve the problem, engineers finally built a "sun-bonnet" around the bearing that reduced temperature fluctuations by fifty per cent.

Then, because the bearing must support a million-pound load, engineers had to bend it literally out of shape so that it would be squeezed back into a perfect circle when the telescope rested on it. Some idea of the meager tolerances engineers had to work with can be gained from the fact that the telescope must be sighted with an angle of error so small that at three miles two lines drawn from a single point would be only an inch apart.

1947...Figuring to Go Places!

It's never too early to start figuring out that "grand tour" . . . and right now many a happy family is mapping out a long-awaited trip to far away places. They know that *tires* won't hold them back . . . for tire replacement, well under way in 1946, will be readily handled in '47. Manufacturers estimate that their output of car, truck and bus tires will be adequate to equip *all* new vehicles, no matter how pleasantly high automotive production figures may run.

Witco plays an important role in the 1947 tire production program as a manufacturer of carbon black, which gives tires their resistance to wear and makes it possible for you to plan a long trip without even *thinking* of tire trouble. (Witco also produces vibration dampeners and rust preventives that make your car ride more quietly and last longer.)

Through 1947, Witco will help many other industries meet *their* stepped-up production figures . . . providing dependable chemicals for use in paints, linoleums, plastics, ceramics, printing inks, leather, paper, drugs and cosmetics.

To go places in '47 . . . figure on Witco!

• • •

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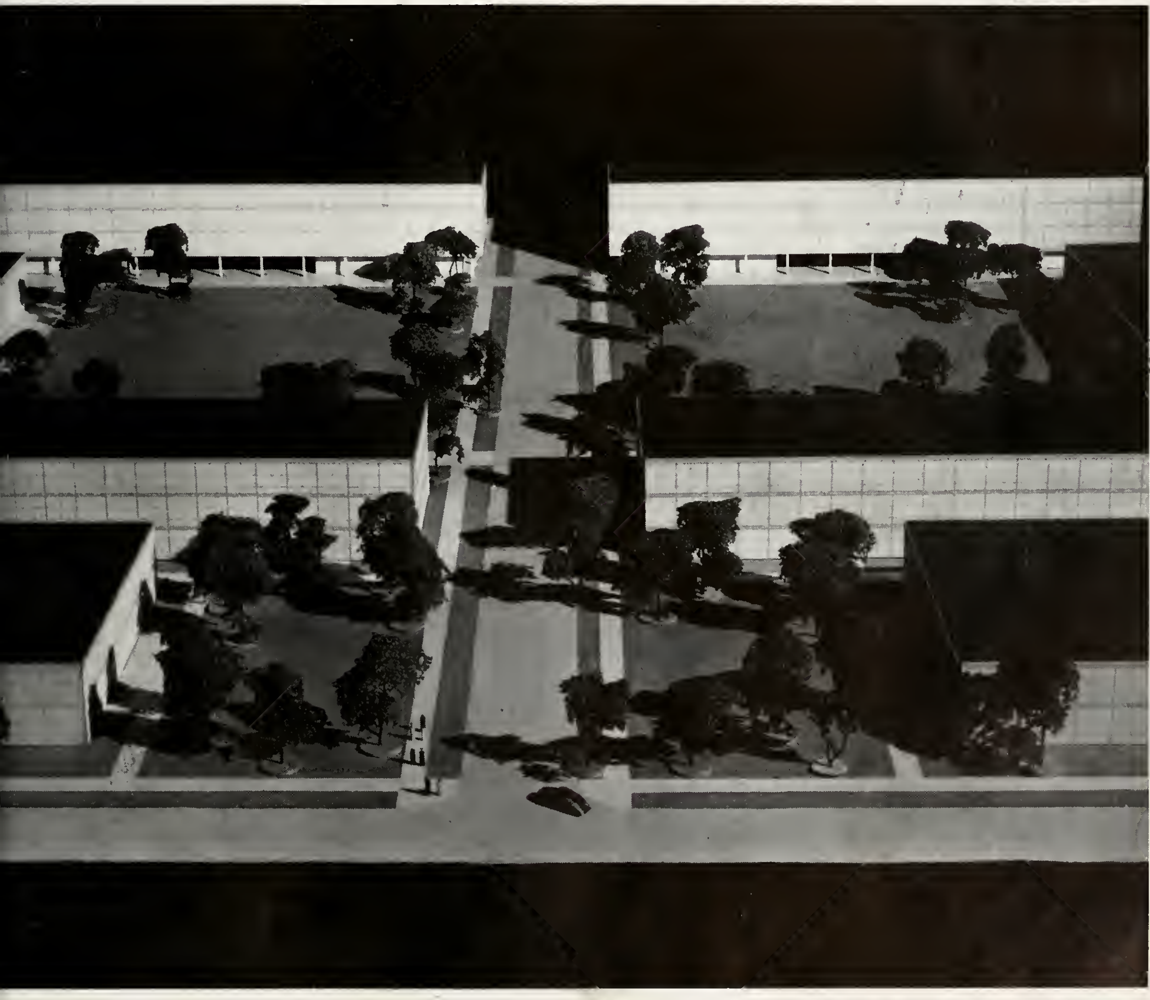
ILLINOIS TECH ENGINEER



MARCH, 1947

EXPERIENCE IS THE BEST TEACHER!

R. J. Reynolds Tobacco Company, Winston-Salem, N. C.

EXPERIENCE TAUGHT MILLIONS THE DIFFERENCES IN CIGARETTE QUALITY!

Result: *Many millions more people found that they liked Camels best.*

IT'S ONLY a memory now, the war cigarette shortage. But it was during that shortage that people found themselves comparing brands whether they intended to or not.

And millions more people found that the rich, full flavor of Camel's superb blend of choice tobaccos suited their Taste to a "T." And that their Throats welcomed the kind of cool mildness Camels deliver.

Thus the demand for Camels . . . always great . . . grew greater still . . . so great that today more people are smoking Camels than ever before.

But, no matter how great the demand, this you can be sure of:

Camel quality is not to be tampered with. Only choice tobaccos, properly aged, and blended in the time-honored Camel way, are used in Camels.

According to a recent Nationwide survey:

MORE DOCTORS SMOKE CAMELS *than any other cigarette*

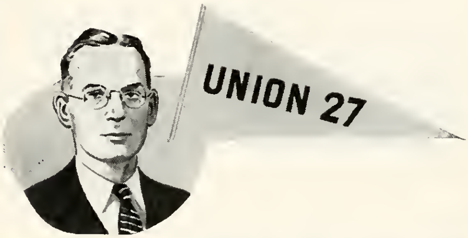
When three independent research organizations asked 113,597 doctors—What cigarette do you smoke, Doctor?—*the brand named most was Camel!*

Campus to GENERAL ELECTRIC

TAX AUTHORITY

The Story of

DONALD MILLHAM



THE average man who stews over the filing of his annual tax return is apt to shake his head quizzically over Donald L. Millham.

While he was in charge of General Electric tax accounting, Don used to file more than 500 returns a year—and like it. In some years the sums he paid out in taxes exceeded the Company's net income by more than four times.

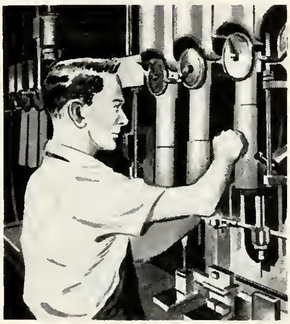
Although he has a new job today—the difficult and important one of Comptroller for the company—Don maintains an active interest in corporate taxation and is still considered one of the company's tax authorities.

A career in corporate taxation problems is, Don admits, short on glamor, long on hard and diligent work. In his early years with G.E. he had learned a great deal about business methods in the company's Business Training Courses, and had worked as an accountant and traveling auditor. But until 1935 he had little more to do with taxation than the filing of his own returns.

Then an opportunity opened in tax accounting. He took the offer and learned the background, the technical language, the legal complexities of his job as he did it.

By meeting the challenges of an exacting and constantly expanding field of endeavor, Donald Millham has made for himself a career with General Electric that is useful and important, and which has held his interest.

Next to schools and the U.S. Government, General Electric employs more college engineering graduates than any other organization.



To help pay his way through Union College, Don worked for General Electric during summer vacations, operating a drill press.

After graduating with honors, he enrolled in the G-E Business Training Course, gained insight into modern business operation.

For five years Don worked as a travelling auditor, made a good record. In 1935, without any prior experience in taxation, he took over General Electric tax accounting.

Learning the job as he worked at it, he became the company's tax authority, filing 500 returns a year. Today he has the difficult and important job of Comptroller.

GENERAL ELECTRIC

CONTRIBUTORS

David P. Boder is Professor of Psychology and director of the Psychological Museum at Illinois Institute of Technology. He received his early training in Russia and at the University of Leipzig, Germany. From 1921 to 1925 he was Professor of Psychology at the National University of Mexico and at the same time directed research in psychology at the Federal district prisons, at the Military College and at the National School of Agriculture. He has his master's degree from the University of Chicago, his Ph.D. from Northwestern University. Dr. Boder has been connected with Illinois Institute of Technology since 1927, first as instructor and subsequently as Professor of Psychology. He founded the Psychological Museum in 1937. During the war he was psychological advisor for the Signal Corps program at Illinois Institute of Technology. During the summer of 1946 he made an interview study of displaced persons in France, Switzerland, Italy, and the American zone in Germany.

Ida Marie Didier, Assistant Professor of Home Economics, received the B.S. degree at North Dakota Agricultural College and the M.S. at the University of Chicago. She has been home adviser with the University of Illinois Extension Service in Coles County, Illinois, has taught textiles and clothing at the Colorado Agricultural and Mechanical Arts College, was head of the home economics department at Marygrove College, and since 1941 has been at the Illinois Institute of Technology. In the summer of 1946 she was a guest teacher in the home economics department at the University of Minnesota. During the war she lectured on "The Textile Situation in Wartime" on the Consumer Education Program for the Office of Civilian Defense. Miss Didier is a member of Chicago Textiles, Clothing and Related Arts Forum, American Home Economics Association, and American Association of Textile Chemists and Colorists. She was a member of the Committee on Revising the Clothing Section of the Standard Budget for the Chicago Welfare Association.

Linton E. Grinter is Research Professor of Civil Engineering and Mechanics at Illinois Institute of Technology. Dr. Grinter came to the Institute from Texas A. and M. College in 1937. He was successively head of the department of civil engineering, dean of the graduate school and vice president of the Institute from 1937 to 1946. He is now devoting his time largely to graduate teaching and the direction of thesis research. In 1946, Dr. Grinter acted as Institute representative at two international engineering congresses

See CONTRIBUTORS on page 4

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IN THIS ISSUE

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GOLDEN JUBILEE

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CONTRIBUTORS

(Continued from Page 2)

held in Paris. This trip gave him an opportunity to trace to their source some of the philosophies of education that he had observed in the training of American and foreign students. His paper published in this issue was written for Latin American readers. It will be published in Spanish in the Spring issue of *Notas de Macmillan* for distribution in Central and South America.

Dr. Walter Hendricks, Professor of English and Head of the Department of Language, Literature, and Philosophy for the past fourteen years, has been a member of the faculty of Illinois Institute of Technology since 1922. In 1934, as Chairman of the Board of Publications, he was instrumental in re-establishing the *Engineer* and *Alumnus* and served as Editor for the first four years. "Bivouac in Biarritz" is a thumbnail sketch of some of Dr. Hendricks' experiences at Biarritz American University which he helped to organize and of which he was Head of the Department of English, in 1945-46. Dr. Hendricks is now leaving the Institute to become President of Marlboro College, in Vermont.

H. B. Michael is in charge of the Burglary Protection Department at Underwriters' Laboratories, Inc. A graduate of Purdue University with the B.S. degree in Mechanical Engineering, he has served in the Automobile and Casualty Department of the Laboratories, and has been in his present post since 1922. He is a member of Underwriters' Laboratories' Burglary Protection Council, of the Western Society of Engineers, and of the Acoustical Society of America. Mr. Michael was formerly consultant to the Scientific Crime Detection Laboratory (Northwestern University).

Hugh J. McDonald is Professor of Chemistry and Director of the Corrosion Research Laboratory. His professional record is reported in the Contributor's column of the December, 1946, issue.

J. Henry Rushton, Professor of Chemical Engineering and Director of the Department, holds the B.S. and Ph.D. degrees of the University of Pennsylvania. He has taught at Drexel Institute of Technology, the University of Michigan, and the University of Virginia; has been engaged in industry and in consulting practice; is author of many publications and contributor to several textbooks; and is co-author of a recent book titled *Process Equipment Design.* During the war he served with the National Defense Research Committee of OSRD as a technical aide and as a section chief. His particular responsibility was correlation of all research

See CONTRIBUTORS on page 60

Bivouac at Biarritz

By WALTER HENDRICKS

Everyone remembers the fierce swift strokes of the last few rounds of the war. They represented the cumulative strength of a military colossus that had grown mightier with each succeeding day. Finally came the knockout, the elation of victory, and then the strange and disconcerting quietness of peace.

For the Army this meant a problem of what to do with its millions of men, because it knew from experience that once the objective is attained morale rapidly disintegrates.

Fortunately, plans had been prepared against this eventuality; and now were set in motion the gears of such an educational experiment as had never before been attempted, either in time of peace or war.

It was a program of education under the direction of the Army to provide courses in skills or studies for all who had the freedom and the inclination to improve their idle time. It included correspondence courses and vocational training, as well as general and technical education both elementary and advanced.

In any far-flung operation, involving elaborate organization, advancement must battle against incompetence and even ignorance, apathy, downright opposition, and partiality. Soon, also the program had to contend with redeployment and demobilization, against which any plan depending on continuity of effort must falter. But criticism or evaluation of the program in general is outside the scope or intention of this article. Here we are concerned with only a small segment, the part having to do with higher education, and particularly at the Army university in France.

Shortly after the conclusion of the war in Europe, a university was established at Shrivenham, England, in a permanent British military installation, besides a technical school at Warton. The problem of finding a site

Dr. Hendricks in uniform of civilian instructor.

for a university in France, however, presented almost insurmountable difficulties. First, there was the demolition of town and city by the invading army, as well as wholesale destruction by the Germans. Then there was the occupation by the armies themselves with their millions of men and the commandeering of needed space and facilities in centers both large and small.

But far down in the southwestern corner of France lay Biarritz, which caught the eye of the directors of the program. Location, climate, opportunities for rest and recreation, and the friendliness of the citizens of the community combined to make this a most fortunate choice. The selection was made about the middle of June. By the middle of July, a faculty of about three hundred instructors had been assembled, and by the middle of August the university was in full operation with three thousand students.

Biarritz is situated on the Bay of Biscay, about twenty miles from the Spanish border. Toward the west lies the Atlantic, toward the south and east the Pyrenees, and toward the north the flat coastal plain. For centuries a sleepy little fishing village, it woke one day to find itself famous, put on the map, as it were, by Napolean III and Princess Eugenie, who erected a pretentious villa, which later was transformed into a palatial hotel. It is the town where Queen Victoria vacationed on her tree-embroidered estate, the town where the gay Edward VII romped, where Spanish, Serbian, and Swedish royalty, Russian nobility, Belgian financiers, and Argentinian cattle-ranchers danced, and gambled, and idled away their time and money. It is the town where, according to gossip, the lover-king Edward met his American lady, for whom he later gave up his crown and an empire.

Gambling casinos and swanky hotels dominate the coast; gay shops, fashionable and attractive, but now depleted of stocks, ornament the avenues; magnificent, but frequently gaudy, villas jostle one another in the town; while quaint Basque houses tie the town together to give it its color and attraction.

This was the town and these were the buildings the Army took over for its university. The Casino Municipale blossomed forth as a library, lecture hall, and theatre. The large room in which stood the games of chance was now bordered with bookshelves and spread with tables made of rough lumber by German PW's. The ornate Palais Hotel and the more modern Miramar stepped out of their role and became barracks for GI's. The once magnificent Villa Begonia now domiciled and entertained American professors instead of Spanish royalty and a European smart set. Other hotels accommodated the various departments of the university, and other villas housed other members of the faculty. Needless to say, the professors, for the most part, lived in a grandeur to which their professional salaries had hardly allowed them to become accustomed, and the GI's enjoyed a vacation such as they may never again experience.

Imagine the thrill of the GI, who having spent two or three years in the thick of battle, could now sink between white sheets in a downy bed in a room overlooking the ocean, and sit at a table with a cloth on it, and with a napkin, and with dishes and tableware, and be attended by a French waitress.

One might conjecture that such comfort and luxury, not to mention the broad beach and the daring bathing costumes, would be a distraction that would seriously compete with the educational process. That they were a fascination, and as much so to the rejuvenated professors as to the adventure-minded GI's, there is no doubt, but that they conflicted with the objectives of the university would be vigorously denied by everyone.

The Municipal Casino, the gambling hall to the right serving as a library, the wing to the left as a concert and lecture hall, and the center as a theatre. The building at the extreme left was used for chemistry, the hotels to the right of it were a few of the many used as student quarters, and the larger building at the extreme right was a department store converted into a GI recreation center.

On the contrary, there never was such a school, never such an assembly of eager and co-operative students, never such a collection of inspired, or at least fervent, teachers. The three-hundred professors came from more than 150 colleges and universities, from forty of the forty-eight states; the students represented all walks of life, all parts of the country, all military units, all races and beliefs, and all military ranks. Within the classroom they were all equal, and the civilian instructors, regardless of their background or position, were plain "mister."

Students attended for eight weeks, and then returned to their units for further orders. Only a small number of honor students were privileged to remain for a second term. Each student carried three courses, of his own selection, in one or more fields, meeting five times a week, for a total of forty hours per course. The ground covered was equivalent to that of a semester at home, and frequently more. The courses were the same as those taught by the professor in his own institution, except that in some instances concessions had to be made because of scarcity of equipment or lack of materials.

This lack, however, was frequently more than compensated for by field trips and special projects. Excursions into the Pyrenees, to quaint Basque villages, to farms, educational institutions, art museums, prehistoric caves, shrines, and manufacturing plants added vitality to a course. Interest never flagged, even though the student had no book, no chair, no heat. There was enough else out of which to make a great course.

Activities were as varied as they were numerous. In the late summer and early fall there was swimming in the surf and promenading along the beach. There were tennis courts, a golf course, an athletic field, and a gymnasium. Sectional winners in tennis and golf, from the European Theater of Operations, came to Biarritz to settle their championships.

A new play was provided each week by the students of the school of drama. Some of these plays were coached by a special director flown from New York or Hollywood. Musical concerts were a continuous repast, frequently interspersed with piano, organ, and violin recitals by talented American soldiers or distinguished French artists. There were unforgettable Basque concerts, vocal and instrumental, and Basque games and festivals, given for the delight and edification of the American soldiers. Lectures were continuous, sometimes two or three an evening, on the subject of marriage, or small business, or what to do with Germany, or the writings of members of the Resistance.

From what has been written, one might gather that here at last was an Army enterprise in which red-tape and irresponsibility played no part. But that is not so. From first to last there was a chorus of complaint. For the GI's, this represented merely a state of mental health, but for the instructor it meant anguish, frequently bordering on despair.

An order for theater equipment issued in July was arbitrarily canceled three days later, but the instructor did not learn of it until the first week in September. Warehouses in Paris were bulging with pianos, but the instructor in music had to get hold of a trailer and pick up what instruments he could find in Belgium. An instructor in economics sent an order for books to headquarters in Paris only to have it returned to him five weeks later for a correct address, which incidentally, was the office next to that of the officer who had returned the order. Heads of departments were rushed from the first convocation to make out, for the third or fourth or fifth time, new orders for books, on the ground that this time

See BIARRITZ on page 46

ENGINEERING AGAINST CRIME

By H. B. MICHAEL

A WORD AGAINST CRIME

Every thirty seconds somewhere in America a burglary, robbery, or theft is taking place. These crimes against property are for profit, and they are largely preventable. Then why not prevent them? Because there are two or three million commercial properties without adequate protection, so that an army of criminals find it profitable to operate. They escape detection and apprehension for awhile and think they are too smart to be caught at all.

Unfortunately, glowing accounts of the criminal's "haul" appeal to and influence thousands of juveniles. According to the F.B.I., more than fifty per cent of persons arrested in 1945 for crimes of this sort were twenty-five years of age or less. Almost forty per cent were less than twenty-one. This is the real danger of leaving property unprotected.

SCIENCE TAKES A HAND

Crime seems to run in cycles or waves, yet it is as old as civilization. Key locks constructed of wood were in use on money chests in Egypt 4000 years ago. Protection, then, is an old art, but it is comparatively new as a science.

Twenty-five years ago prominent underwriting groups began to realize the economic necessity of protection engineered to fit the hazard. Professional crimes were being skillfully planned, timed, and executed. The horse and buggy days were gone. Something was needed to cope with the ingenuity and methods of the modern crook. Underwriters' Laboratories was asked to develop Standards whereby protective appliances could be classified as to merit and be thus recognized.

This approach had been quite successful in fire protection and safety fields. In fire protection, automatic sprinklers were demonstrating an enviable record of controlling almost ninety-seven per cent of fires involving them. Was it possible to approach such a record in outwitting the criminal? It was possible and it has been done. During the past ten years, approved automatic burglar alarms have operated as intended in more than ninety-seven per cent of all attempts on mercantile protection. Bank vault alarms have an even more impressive record of no successful attempts in twenty years. Usually insurance underwriters recognize these installations so that often they literally pay for themselves in a few years.

High velocity and high kinetic energy small arms used in testing bullet-resisting glass.

THE REASON WHY

Let us examine the reasons for such a performance record. The burglar alarm will serve as an example. From the beginning, the Laboratories' Standards have required closed-circuit, self-supervisory and self-powered systems with electrical as well as mechanical tamper-protection on all vulnerable components. To illustrate, all protective wiring and attachments operate so that failure of connections or deliberate cutting of wires by a burglar originates an alarm or trouble signal. A cross between adjacent circuits produces the same result. In Class A (or Grade A) systems and most Grade B systems, grounding of the wires will not render the protection inoperative.

Local alarms are required to have the large outside gongs protected by steel cases, electrically "tampered" and operated from well-protected batteries. Thus it will be seen that these systems are of the low-voltage, self-contained type. It matters not if burglars cut all outside or exposed wires—the system will continue to function. The systems do not depend on 110-volt

Checking the speed of operation of a vault door locking-device when a torch is applied.

supply as do ordinary electrical appliances. On the contrary, they usually operate on 6 volt with a few thousandths of an ampere supervisory current. Naturally, the sensitive nature of such systems suggests correspondingly rigid tests to determine reliability of operation. For example, tests on 6/10 of rated voltage, and for effects of vibration, dust, corrosion, high and low temperature, rain and humidity are standard procedure.

IMPORTANCE OF MAINTENANCE

Assuming that circuit design and construction is engineered to fit the service, suppose the batteries fail? What about maintenance? A fair question and an important one.

Every burglary and robbery-protective installation bearing the Laboratories' Certificate—more than 25,000 of them—is required to be under care-contract and service of the listed installing company. Without such service an operational "batting average" of better than ninety-seven per cent over a period of years would be impossible. Service companies make regular inspections yearly, quarterly, or oftener if necessary, to maintain uninterrupted service.

CHECK AND DOUBLE CHECK

There is still another reason for excellent field performance. In this unique protection field, the supervision by Underwriters' Laboratories, Inc. does not end with periodic re-examination or inspection and labeling of devices at the factory. The factory supervision is supplemented by inspection and test of a substantial percentage of installed systems wherever they may be located. In the case of central station type of alarm systems, the supervision includes surprise test alarms, night visits to stations, review of response records, and numerous other service items. In addition, the certificate of classification on each installation covers extent of protection, that is, whether partial or complete, whether openings only, or walls and floors as well as openings are protected. Thus, the Laboratories' supervision includes a check of installation methods which, in the case of fire protection appliances, are covered by Codes of inspection bureaus, and of city, state or other authorities.

PRINCIPLES OF DETECTION

There are many principles besides closed-circuit interruption used in in-

See CRIME on page 52

TEXTILES

By Ida Marie Didier

Not many years ago there were only four major fibers in use for clothing, household fabrics and other textile uses; these four were wool, silk, linen and cotton. Then rayon, a synthetic fiber, was discovered in the chemical laboratory and following that a great variety of man-made fibers have made their appearance each with its own particular qualities and characteristics. The first rayon was produced in 1885 but not until 1927 did it make any real progress as a fiber in our textile markets. Since then it has become of major importance. In 1939 the total rayon consumption in the United States reached 4,532,300,000 pounds; in 1945 the figure was 5,923,900,000 pounds and in the first half of 1946 we consumed 3,172,300,000 pounds. The use of rayon is on the increase especially since improvements on the fiber itself have been made and the ever increasing numbers of new finishes have been added to give it new qualities and thereby making it more desirable for the many purposes for which it is used.

During the last ten years fiber-glass, nylon, vinyon, aralac, velon, saran and plexon have made their appearance in a variety of textiles. Peanut fiber and redwood fiber which have had considerable publicity have not yet appeared in fabrics on the market. In addition to these fibers we hear about alginate fibers which have been manufactured in some foreign countries as well as terylene, a new polyester fiber still in the experimental laboratory in Great Britain. When and if it will be produced depends upon source materials, equipment and the cost of production. A new fiber reported from Italy is called piumtal; it is said to have wool characteristics. The raw materials used are cellulose, soda, sulphur, coal, and casein or feathers. When it will reach our markets is unpredictable. It all depends again upon availability of raw materials, manufacturing facilities, and cost of production.

Textiles are going through a period of change, expansion and development. These changes had begun before the war, but due to the many military needs and uses, they were speeded up and developments came rapidly during the past few years. The changes were developments of the new man-made fibers and also included improvements of the older accepted materials.

Fiber and fabric developments have been constantly placed before the public in the daily papers, magazines and by other means of publicity, often leading the consumer to form the opinion that a trip to the retail store would find the article readily available. Many of these so-called new developments are still in the experimental stage, some are making their appearance and will be available in very limited quantities, some will never prove to be satisfactory nor desirable.

Wool, which is one of our oldest fibers, has had many new qualities added to its previously existing properties. Washability has been one of the most desired qualities. In a recent survey made of 120 of the country's leading department stores, ranging from the style leaders to stores specializing in large volume distribution, eighty per cent asked for washable wools. This information, coming from thirty-five states, represented the opinion of merchandising managers, buyers, and sales people as well as top

A study of labels in the identification and care of fabrics.—Thelma Samotny.

Study of construction of fundamental weaves. Subject being woven is twill. Professor Didier and Audrey Brinkerhoff.

executives. Now washable wools are becoming a reality; however, due to lack of equipment, labor shortages, scarcity of materials, and other factors we find only limited quantities coming on the markets. It is possible that very little will be available before fall.

There are several methods employed in shrinkproofing wools to make them washable. Wool shrinks progressively—that is, the first washing does not take out all the shrinkage in the fabric—it can shrink each time it is laundered. However slight that amount may be, it is a decided disadvantage in any textile fabric. The process employed must control this factor so that a stabilized textile results.

The chlorinating method of producing washable wools was first perfected in Great Britain before the war. It was used very successfully in treating wool socks for our military forces and saved our government millions of dollars on that item alone. In the process some of the outer scales are removed and the inner and outer layer of cells fuse, thereby reducing the shrinkage. The wear resistance is also increased thirty per cent. The process is applied to knitted materials.

Probably the greatest development in the production of washable wools has been by the resin treatment method, whereby the resulting fabrics have not over a five percent residual shrinkage. Some manufacturers claim not over three per cent residual shrinkage for certain fabrics so treated. The wool fiber is impregnated with resin in the finishing process and the tendency of the fiber to shrink or felt is removed. The fabric remains soft and fine, it will not stretch or sag, and has crease-resisting qualities. Slight changes in the construction of the material as well as changes in yarn sizes were necessary to produce good results. These changes have had tremendous bearing on the type and amount of shrinkage obtainable as well as the feel and hand of the cloth. This treatment is applied to both woven and knitted fabrics. Resin finished wools are beginning to make their appearance on the market in ready-to-wear goods. It will take a

longer time to find yard or piece goods so treated, since the available supply will go to the garment manufacturing industries first.

A new process has been patented for shrinkproofing wools, which also eliminates felting, increases resistance to abrasion 100 per cent, and assures undiminished tensile strength in the fabric. The process can be combined in one operation with mildewproofing and waterproofing the material.

Felts for hats are being made water resistant by impregnating them with an aqueous dispersion of synthetic resins in combination with a plasticizer for the resin. The ultimate shrinkage reached is somewhere from five to ten per cent. The felt possesses a leather-like quality, being very compact, having high tensile strength, and with a good resistance to water penetration. This process would solve some of our rainy weather problems. It is a British patent.

Wool fabrics are and will play a prominent role in the fashion picture. Manufacturers are now producing materials which are fast in color to sunlight, cleaning, washing, and perspiration as well as other factors. The improvements in dyes have been very extensive during the past few years.

Australia is experimenting with the production of fine light-weight woolens weighing four ounces per square yard instead of the previous six to eight ounces. Some fabrics as fine as 2½ ounces per square yard have been produced. These could be used for all-year-around wear. It is claimed that these wools will be washable, easy to iron, non-crushable, and mothproofed when they reach the market.

Mothproofing of wools has been in progress for some time. This is a much needed improvement since moth damage to wool fabrics runs into millions of dollars per year in our country. Some fabrics carry a lifetime guarantee for the process employed. In others the finish has to be renewed. There are dry-cleaning establishments which will renew the finish on request at additional cost when cleaning the article.

Cotton, the "King" of fibers, since it is most abundant, most wide-spread in use, and usually the cheapest, has had many improvements to put it into the limelight. Shrinkage control, which first made its appearance under the sanforization patent, with a resulting one per cent residual shrinkage, has had other processes applied to achieve the same results. Other mechanical processes similar to sanforization have been patented; there are also resin treatments. This is very important since the chief method of cleaning cotton fabrics is by laundering. The resin treatment, in addition to controlling the shrinkage, imparts a crease-resisting quality to the fabric. The resin treatment has been retarded by lack of equipment and by the need of more extensive research to eliminate some undesirable factors such as chlorine retention in the fabric which weakens the material during laundering.

Water and wind-repellent cotton fabrics were with us before the war; however very extensive research was carried on during that time to improve these qualities as well as to make the finish permanent to laundering and dry-cleaning. Fabric construction was found to be an important factor in securing good water and wind-repellency. The treatment was not permanent after several dry-cleanings or launderings and the finish had to be renewed to serve the purpose effectively. Some dry-cleaning establishments are equipped to renew such finishes. Fabrics which are water and wind-repellent also possess stain-resistant qualities.

Many starchless finishes have been perfected; however few are reaching our retail counters. Before the war we had such a finish applied to sheer and light-weight cottons; now new developments are applying similar finishes on heavier fabrics such as are used for nurses' and dietitians' uniforms and are claimed to withstand commercial laundering without losing their crisp stiffness.

Minor modifications in the manner of application of the thermosetting crease-resisting resins has given us permanent chintzes durable to moisture and to laundering.

A new cotton elastic fiber has been achieved by twisting cotton yarn into the shape of a coil spring. This can be made in various degrees of elongation. It is claimed that this yarn will withstand repeated laundering or dry-cleaning. It is not made to replace lastex or other elastic materials. Uses for it are visualized in slip covers, sweaters, gloves and surgical bandages.

Non-woven fabrics employing cotton fibers have had wide publicity. Since 1940 non-woven cotton fabrics have been on the market and a development of this type of fabric to extend its use is under way. Two of the processes in common use to secure strength in these fabrics employ vinyl resins. The first prints lines or outlined squares on the cloth. The second blends vinyl yarns with the cotton staple. Heating causes the vinyl resins to fuse and bond the cellulosic fibers together. This development is still too new to permit evaluation of its possibilities.

A new finish is giving cotton the luster and feel of silk. Garments of such materials are making their appearance in ready-to-wear goods.

Extensive research is being carried on to improve cotton materials in order to compete with textiles made from other fibers now on and coming onto the market.

Rayon, which is a major textile fiber in use today, is made by the viscose, cuprammonium and acetate processes. The first two are classed as regenerated celluloses and the third as cellulose acetate. Sixteen companies with twenty-seven factories manufacture all the rayons produced in the United States. Rapid strides in the improvement of rayon have been made just preceding and during the war. High and medium tenacity yarns made their appearance and were used where strength both wet and dry was very important. These found their way into military uses, but now are becoming available for textiles in the retail market. Low tenacity rayons were improved, so that their breaking strength both wet and dry was practically doubled. One company forecasts a rayon that will stand the same laundering as given to cottons. Fortisan, a new high tenacity rayon of the regenerated cellulose type, has been produced. It is made in extremely fine filaments and possesses great strength both wet and dry. During the

See TEXTILES on page 40

THE CORROSION OF METALS

AN ECONOMIC PROBLEM READY FOR SCIENCE

By Hugh J. McDonald

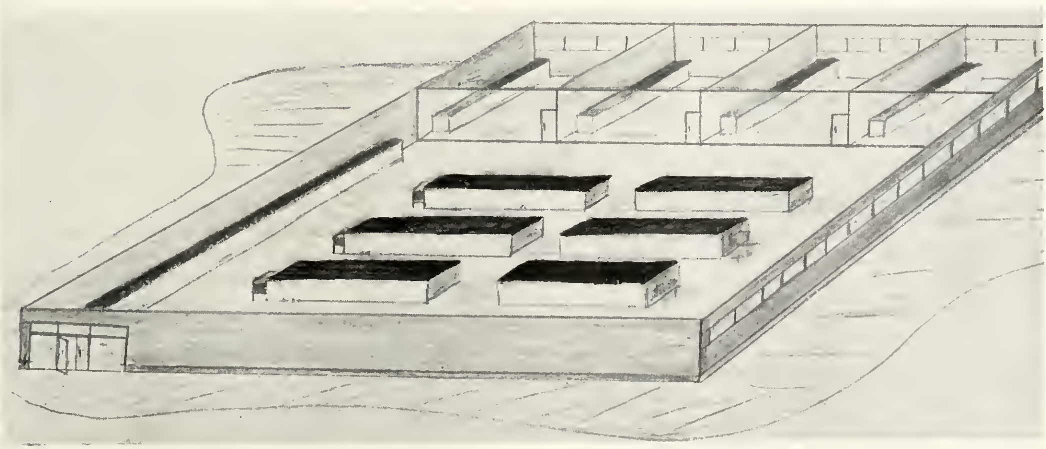
Part II

Controlling Factors In Corrosion Reactions

POLARIZATION AND OVERVOLTAGE

The galvanic cell or couple potentials which were discussed in the first part of this paper were reversible potentials, that is, potentials developed when all of the free energy liberated in the reaction was converted into electrical energy. All processes for the conversion of energy from one form to another become less efficient as the speed of the conversion is increased, increasing portions of the available energy being dissipated as heat. This applies to the galvanic cell. If current is taken from a cell at a rapid rate, only a fraction of the energy liberated in the cell reaction is converted into electrical energy and the voltage drops. The difference between the reversible (maximum) voltage and the actual voltage is called polarization. A dissipative effect of the kind responsible for this phenomenon is sometimes referred to as an irreversible effect. There are dissipative effects due to the resistance of the electrolyte between anodic and cathodic surfaces, to the resistance of the external circuit between anode and cathode, and to polarization effects at the anode and cathode. These latter polarization effects are made up of concentration polarization at the electrodes, of possible anodic and cathodic overvoltages due to some slow process in the over-all electrode reaction, and to the resistance of films on the anode and cathode surfaces.

The concentrations of substances right at the electrode are those which determine the potential of an electrode. It should be evident that as electrode reactions proceed the concentrations in the immediate vicinity of the electrode will be different from those in the main body of the electrolyte, because as the process continues ions



Sketch of new Corrosion Research Laboratory to be located in the Chemistry Building now under construction. (Drawn by J. T. Waber.)

or molecules must diffuse away from or into the film adjacent to the electrode. The concentration gradients which are set up about the electrodes when a cell or couple is discharged at an appreciable rate cause a back electromotive force which is called concentration polarization.

Even though concentration polarization effects are reduced by the addition of suitable depolarizers, such as manganese dioxide in the ordinary dry battery, there is still a polarization effect noticeable in many electrode reactions. Polarization of this kind which cannot be attributed to any other cause is known as overvoltage.[4] Overvoltages may be of considerable magnitude, especially in electrode reactions that involve gases, such as the discharge of hydrogen or reduction of oxygen at cathodes, and the discharge of oxygen, chlorine, etc., at anodes. Overvoltage depends upon a number of variables; it increases with current density, reaching a maximum at high current densities, and it decreases with an increase in temperature. The magnitude of the gas overvoltages depends upon the nature of the electrode. For example, hydrogen overvoltages are low on platinum, gold and silver, intermediate on iron, nickel, cobalt, carbon and copper, and high on lead, zinc, cadmium and mercury. Finally, overvoltages may be increased by the addition of suitable substances to the electrolyte; for example, hydrogen overvoltages are increased by the addition of such substances as glue, gelatin, and the types of substances used as inhibitors in acid pickling of iron and steel.

Films on an anode or cathode surface, separating these areas from the main body of the electrolyte, will increase the anodic or cathodic polarization. They cause an increase in the resistance of the path between anode and cathode, and they decrease the rate of diffusion of reactants and products of the electrode reactions toward and away from the electrode surfaces, thereby increasing concentration polarization to values that may be much higher than those which would prevail in the absence of the films.

The more adherent and non-porous the film, the more it will serve to increase the polarization at an electrode, but even porous, loosely adhering films may exert a pronounced effect. These films, whether they are naturally formed on metal articles during manufacture, are formed by application of special coatings, or consist of corrosion products, play an important role in determining the rate of attack of an environment upon a metal or an alloy.

LIMITING CORROSION RATE; ANODIC AND CATHODIC CONTROL

The reversible voltage of the corrosion couple may be considered the driving force of the corrosion reaction. As has been mentioned, each of the dissipative effects which together make up the total polarization increases as the amount of current flowing between anodic and cathodic areas is increased. If, therefore, corrosion proceeds by an electrochemical mechanism, it may be concluded that the steady-state corrosion rate will be the rate that makes the sum of all the dissipative effects, expressed as counter potentials, equal to the driving force of the corrosion couple. It is evident, then, that anything that will increase the resistance of the electrolyte, or the total anodic or cathodic polarization will decrease the corrosion rate. This conclusion is useful in searching for a means of decreasing the corrosion rate in a given system.

In most cases, the anodic and cathodic polarization are large compared to the "IR drop" (that is, current flowing $\times$ resistance of electrolyte) between anode and cathode areas. Also, since polarization makes anode areas less anodic and cathode areas less cathodic, the two areas are being brought to the same potential as the polarization increases. If the "IR drop" of the electrolyte may be neglected, the corrosion rate that will yield sufficient polarization to bring the anodic and cathodic areas to the same potential will be the limiting corrosion rate.

If anodic polarization is the predominant dissipative effect, the corrosion process is said to be under "anodic control". The corrosion of aluminum, stainless steels, and other metals that form adherent, nonporous films on their surfaces are examples of processes under anodic control. In any attempt to apply protective measures, it is important to recognize the type of control that prevails in the unprotected case.

In the attack of zinc by acids leading to hydrogen evolution, the process is certainly under cathodic control, the overvoltage for hydrogen evolution at cathode areas being the most important contributor to the total polarization.

The attack of an environment upon a metal or an alloy usually leads to the formation of a corrosion product which is insoluble in the environment. The film of corrosion product tends to stifle the corrosion process by increasing anodic polarization, cathodic polarization, or the resistance between anodic and cathodic areas. There are films that afford all intermediate degrees of protection from that offered by a spongy mass, which merely hinders the diffusion of reactants and products, to that given by adherent, practically nonporous and insoluble films that cause some metals and alloys to become passive.

All metals, except the very noble ones, when exposed to air at room temperature or at higher temperatures react with oxygen to form an oxide film on the surface. If the oxide has a lower specific volume than the metal, the film must shrink and crack, providing channels for the further rapid access of oxygen to the metal. Such films, which are not protective, are found in the case of the active metals, lithium, sodium, potassium, calcium, strontium, barium, etc.

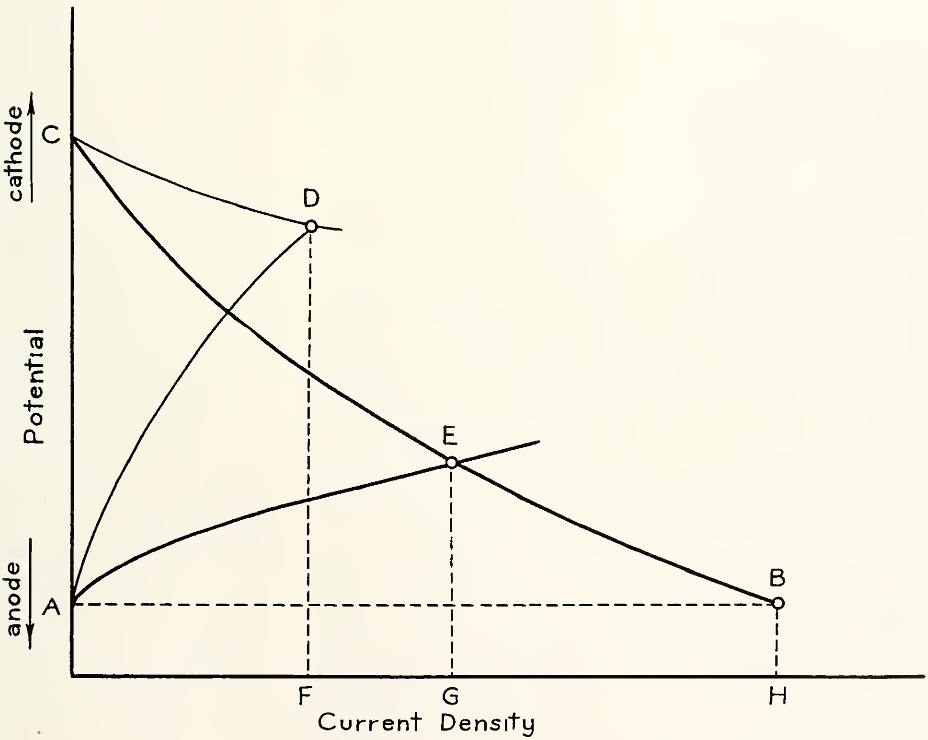
When, however, the oxide has a higher specific volume than the metal, the oxide will be formed under compression and, at low or moderate temperatures, the metal will be completely covered and the protection may be complete when the film has grown to only a few molecular layers in thickness. Films of this type are formed on copper, brass, tin, lead, iron, nickel, monel metal, stainless steel, zinc, chromium, aluminum and a number

[4] S. Glasstone, "Overvoltage and Its Significance in Corrosion," *Corrosion and Moterial Protection*, Vol. 3, No. 6, Page 15, July, 1946.

of other metals and alloys when they are exposed to relatively dry air. These films are responsible for the relative permanence of these metals and alloys under atmospheric exposure. Although passivating films are most commonly produced when metals are exposed to air, they are formed in some cases by aqueous solutions. The classical case is the passivating film formed on iron by dipping momentarily in concentrated nitric acid. The iron when so treated will no longer replace copper ions from copper sulfate solution or even react with dilute nitric acid. In general, anions that are oxidizing and anions that form very insoluble compounds with the metal tend to aid in film formation and film repair. Thus, the soluble chromates, phosphates, silicates, borates and hydroxides in proper amounts are used to give protection to iron and steel in aqueous mediums. Except for the unusual cases, such as iron in concentrated nitric acid, most protective oxide films are destroyed if the aqueous medium is made acid. The presence of many anions such as chloride, bromide, iodide, etc., will cause film breakdown and accelerate corrosion as in the familiar "salt spray" test and in exposure to sea water.

INHIBITORS

Any substance that, when added to the environment of a metal or alloy, decreases the corrosion rate is called an inhibitor. The use of chromates, phosphates, silicates, etc. to decrease the rate of corrosion of iron and other metals serves as examples of anodic inhibition. In general, they help form or keep in repair a protective film on the metal surface. The addition of magnesium or zinc salts will decrease the rate of corrosion of iron under conditions of partial immersion. At the cathodic areas near the water line, the alkalinity is increased as oxygen from the air is reduced to hydroxyl ions, leading to a precipitation of magnesium or zinc hydroxide over the cathodic surface as a porous but some-



Schematic diagram to illustrate reaction under anodic and cathodic control and principle of cathodic protection.

AE and AD; anodic polarization curves.
CB and CD; cathodic polarization curves.
AD and CD, together, represent reaction under cathodic control.
AE and CE, together, represent reaction under anodic control.
F and G represent limiting corrosion current and therefore limiting corrosion rate.
B represents minimum potential to which cathode must be polarized in order to insure cathodic protection of anodic area.
H represents minimum current required to maintain cathodic protection of anodic area.

what adherent deposit. To reach the cathodic surface, oxygen must diffuse through these deposits and its rate of arrival is therefore decreased. These substances function, therefore, as cathodic inhibitors.

Another important class of inhibitors consists of organic substances. They include many compounds all the way from those of unknown structure obtained as by-products from petroleum refineries, packing plants and coal-tar products to highly complex synthetic organic chemicals of known structure and composition. In general, organic inhibitors contain nitrogen, oxygen or sulfur, and include many aliphatic and aromatic amines, heterocyclic nitrogen compounds such as pyridine and quinoline, substitution products of urea and thiourea, mercaptans, organic sulfides, aldehydes, ketones and some organic acids. The inhibitor may be soluble, or colloidally dispersed, such as gelatin or glue. It usually consists of a hydrocarbon part attached to a polar or ionizable group. Part of the effectiveness of such compounds is due to their ability to become attached to the surface of the metal through the polar group, and to cover the surface somewhat like large weeds in the botttom of a slow stream. In general, the larger the "shadow" cast by such large molecules, attached at one end to the metallic surface, the greater their relative merit in inhibiting corrosion.

SURFACE CONVERSION COATINGS

A large number of preventive measures have been introduced to combat corrosion, each designed to meet a particular need, and all are more or less successful so long as the application is kept well within the limits of the conditions for which provision is made. For this reason, corrosion has sometimes been referred to as "the common cold of the steel industry". A few of the more important of these processes will now be discussed.

A number of metals owe their resistance to corrosive attack to the fact that exposure to oxygen results in a film of the metallic oxide being produced which forms a barrier to further attack. Aluminum and its alloys provide an example of this form of protection. The film of oxide is of submicroscopic thickness, and it is obvious that the protection would be more effective if the film were thicker. Anodizing is a process for building up this protective film. The aluminum article is made the anode in an electrolyte cell, using a cathode of graphite. Various electrolytes such as sulfuric, oxalic and phosphoric acids and ammonium sulfide have been used, but a three percent solution of chromic acid finds general favor.

The appearance of the film varies with the process; the chromic acid treatment gives an opaque film while the sulfuric acid bath gives a film having a translucent silver appearance. Any anodized film will adsorb dyes, to give highly colored ware, and other anticorrosive agents, such as lanolin, which protects against severe conditions. The films also offer an excellent bond for paint or enamel. Although the anodizing process was first developed on a commercial scale for aluminum and its alloys, it has been extended to other metals such as brass, cadmin, chromium, copper, nickel, tin and zinc.

Parkerizing and Bonderizing are the best known of a number of processes which aim at developing on iron and steel articles a film of ferrous phosphate. The processes are varied by the inclusion in the bath of small quantities of metallic salts in addition to manganese dihydrogen phosphate. In every case the process is very simple and consists only in immersing the articles to be treated in a hot solution of the salts for five minutes or so, after which they are rinsed in hot water and dried. Besides its anticorrosive properties, steel treated by one of these processes offers a bond for paint or enamel superior to the bare metal.

In the Corronizing process, the article to be protceted is cleaned and given two successive applications of thin electrodeposited coatings, using two different metals, nickel, and zinc being the more common combination, but nickel and cadmium have been employed. After washing and drying, the deposits are heat treated. The process affords very effective protection even under severe conditions.

The Bower-Barff process, used for ferrous metals, consists in heating the parts to a red heat and exposing them to superheated steam in a closed chamber. This causes a film of black magnetic oxide to form on the surface, which affords a considerable measure of protection against further attack. The process is the basis of several methods of preparing rust-resisting iron-ware, such as "Russian iron" used in making stovepipe.

In the Sherardizing process, used for small articles, iron objects are packed in zinc dust and heated for a few hours at about 250°C, during which time the zinc penetrates the iron to a considerable extent even though this temperature is well below the melting point of zinc. This penetration of zinc into the iron at temperatures where alloying cannot occur apparently yields a protective zone which is superior to the iron-zinc alloying that occurs in hot-dipping.

Protective layers are added to iron products in various other ways. When iron is dipped in fused potassium nitrate, it is coated with a firm layer of Fe_3O_4 which imparts a blue color that is familiar in fish hooks, small firearms, etc. Sometimes the iron is covered with a protective layer of a more noble (cathodic) metal such as those used in metal spraying, in nickel or chromium plated ware and in tin plate.

Experiments have been tried on various treatments which may be given to the cold metal, whereby paint may be safely applied after the removal of loose scale only. One of the most promising of these consists in spraying the surface simultaneously with solutions of two salts which will precipitate an insoluble salt having anticorrosive properties. Solutions of zinc sulfate and potassium chromate have been tried. Both salts are freely soluble in water and the solutions readily find an entrance into the fine cracks in the scale by capillary attraction, where they interact to precipitate the insoluble zinc cromate. Another combination is lead nitrate and sodium phosphate which precipitate lead phosphate. The process has the advantage that a dry surface is not an essential requirement for commencing operations, and although the application must dry out

before painting is begun, a trace of moisture is not serious since it is countered by the inhibitor.

CORROSION INHIBITING PAINTS

A film of paint or other material applied to the surface of a metal with a view to protecting the latter against corrosive attack may operate in two ways. It may be merely mechanical in action and claim no other merit than the total exclusion of air and moisture from the metal. Most lacquers, enamels, and paints have this as their objective. If this is done effectively, nothing more is desired; but this total exclusion over any length of time is not easy to attain. Other films, while claiming mechanical coverage among their merits, depend in large measure upon some chemical action which tends to make the metal surface immune from corrosive attack. Covering the surface with zinc by dipping the object into the molten metal, a process known as galvanizing, is an example of this action.

Much work has been done in recent years on anti-corrosive pigments in paint. Such paints not only protect by mechanical cover, but may be expected to offer some protection after the paint film commences to fail, as it certainly will in course of time. As a priming coat, red lead is almost without a rival. Many pigments have been suggested for inclusion in paints, but they are mostly confined to salts of lead, zinc, nickel and cobalt, the acid radicals being usually the phosphates and chromates. Metallic dusts, such as zinc, have shown some promise.

Aluminum paint is good as a second coat, as the tiny flakes of aluminum arrange themselves like fish scales parallel to the surface of the paint film and since the flakes are opaque, they exclude the ultraviolet light from the sun's rays, which is one of the chief sources of destruction of paint films.

ELECTRICAL PROTECTION

Since metal oxidation in corrosion always occurs at anodic areas, it would seem logical that one might protect a metallic structure by making the structure cathodic through the use of an externally applied electromotive force. To give complete protection, sufficient current must be passed, with the structure as cathode, to polarize the entire surface up to the potential of the local anodes. Some important applications of the method known as cathodic protection have been made to underground pipe-lines, water tanks, etc. Although difficulties involved in obtaining proper current distribution and the cost of the electrical energy consumed when sufficient current is passed to give protection are limiting factors in the general application of the method of electrolytic protection, it is finding wider application every year. The literature on the subject, in theory and applications, has been so voluminous that it will not be pursued further in this article. Instead, a reference[5] is hereby given to a key paper which will lead the interested reader to the heart of the subject.

STRESS CORROSION CRACKING AND CORROSION FATIGUE

The earliest record of stress corrosion cracking was given by Roberts-Austen in 1886. A piece of gold-copper-silver alloy, when moistened with ferric chloride solution, developed a large crack within a few seconds time. The phenomenon has been known by various names, such as boiler and caustic embrittlement, season cracking (of brass), and finally, stress corrosion cracking. It is now known that few commercial metals escape stress corrosion attack, which is penetrating and selective in its path; in some metals like mild steel, it results in intergranular failure, while in stainless steel, the attack is transgranular. Brass, bronze, steel, aluminum and magnesium alloys, stainless steel, zinc die-castings, precious metals, —all crack by stress corrosion. This type of failure is insidious since it is so destructive of metallic strength yet the structure may show very little visible weakness; even a close inspection of a boiler or artillery shell may be quite reassuring, yet boiler explosions or shell failures may occur.

A number of theories have been advanced to explain the phenomenon, but the most satisfactory is the "stress accelerated precipitation theory",[6] which is general in its application. It states that (given the presence of a tiny crack which may have been formed by an attack of the grain boundary or in some other way) high stresses are formed at the apex of the crack by stress concentration and the local deformation accelerates the decomposition of the parent solution. If an anodic phase, with respect to the matrix, forms during such decomposition, it is the resultant galvanic cell that accelerates the stress corrosion attack. In the case of mild steel, the precipitated phase is Fe_4N; in stainless steel, the anodic phase is a martensitic decomposition product of the parent austenite. The theory states that at the bottom of a crack, the high, concentrated stresses cause local straining, the decomposition of the parent solid solution is accelerated, the phase resulting from the precipitation or decomposition is anodic to the parent matrix, the crack propagates by the dissolution of this newly-formed anodic material and that the process of strain-accelerated decomposition goes on continuously ahead of the zone of chemical attack.

It has been shown that stress corrosion, for mild steel at least, can be prevented by shot peening and mild nitriding, both processes which introduce compressive stresses at the surface. A treatment at 700°C with hydrogen saturated with water vapor removes nitrogen from mild steel, thus preventing the formation of iron nitride and consequently eliminating stress corrosion. The addition of so-called "nitrogen scavengers", elements like aluminum and titanium which remove nitrogen from the steel by forming stable compounds, are also effective. Finally, on the basis of laboratory tests, anodic-type inhibitors and cathodic protection are found to be very effective.

A phenomenon closely allied to stress corrosion cracking is "corrosion fatigue", which results when a metal or alloy is subjected to alternating cycles of applied stress, while in con-

See CORROSION on page 56

[5] R. H. Brown and R. B. Mears, "Cathodic Protection," *Trans. Electrochem. Soc.* Vol. *81* 455 (1942)

[6] J. T. Waber, *Doctorate Thesis,* Illinois Institute of Technology, 1946; also J. T. Weber and H. J. McDonald, *Monograph on Stress Corrosion Cracking of Mild Steel,* Corrosion Publishing Company, 1131 Wolfendale St., Pittsburgh, Pa. (in press)

The Displaced People Of Europe [1]

Preliminary notes on a psychological and anthropological study

By DAVID P. BODER

A few days after the surrender of Germany, General Eisenhower, then Supreme Commander of the Allied Forces, sent out a call to the editors of American newspapers which may be summarized in five words, "Come and see for yourself." It seems that this valiant soldier, preoccupied as he might have been with his unprecedented duties, has found time to reflect upon the immeasurable historical significance of preserving for posterity the impressions and emotions aroused by the picture of thousands of innocent victims dead or dying in the liberated concentration camps.

While reading about General Eisenhower's call to the editors, it occurred to me that a new historical tool had been made available right on the campus of Illinois Institute of Technology. As a teacher of the course in perceptual education, I could not help observing that while literally hundreds of thousands of feet of visual material was collected to preserve the details of the war, practically nothing was preserved for the other perceptual avenue, the avenue of hearing. The magnetic wire recorder developed by the Armour Research Foundation appeared most suitable to fill this gap.

In a memorandum on the subject dated April 30, 1945, I wrote as follows:.

(1) For psychological as well as historical reasons, it appears of utmost importance that the impressions still alive in the memory of displaced persons of their sufferings in concentration camps and during their subsequent wanderings, be recorded directly not only in their own language but in their own voices.

Dr. Boder at Dachau.

(2) It seems impossible that there were or are enough newspaper correspondents knowing the language of Russian, Polish, Jewish, Latvian, Lithuanian, Mongol, Dutch, Flemish and even German sufferers in concentration camps and establishments of forced labor, so that such reports could be recorded with sufficient detail and precision for contemporaries as well as posterity by the usual "paper and pencil" method of interview. These people are entitled to their own Ernie Pyle, and since that appears practically impossible, the exact recording of their tale seems the nearest and most feasible alternative.

Although the importance of such a project appeared obvious, it took more than a year to carry out the necessary formalities and to find the means for the "expedition". The aim was finally realized in the summer of 1946 as a joint project of the Illinois Institute of Technology and the Psychological Museum. We reserve for another publication the listing of the names of members of the administration, faculty and alumni of Illinois Institute of Technology as well as of the trustees and friends of the Psychological Museum who made this expensive and in our opinion important project possible.

I arrived in Paris on Saturday, July 29, 1946. My scientific equipment consisted of a model 50 wire recorder, 200 spools of wire, and an assortment of converters and transformers. I had my visas for France, Switzerland, and Italy, and my clearance for Germany was still pending in Washington.

My first problem was to get located. With the help of some friends residing permanently in Paris I got lodging at the Grand Hotel. It soon became ob-

[1] Copyright by David P. Boder.

vious that my choice of residence was a wise one. From the entrance of the hotel I had a reasonable chance to get a taxi, at least in the daytime. Considering that the recorder, a one-day supply of spools, and necessary accessories amounted to a load of about sixty pounds, my urgent dependence upon transportation by automobile becomes obvious. Moreover, the displaced persons were housed in villas and semi-public buildings located mostly in the outlying districts of the city and in the suburbs. Under these circumstances my bills for transportation, often at black market rates, ranged from five to twenty-seven dollars a day.

On the day of my arrival, a Saturday, I was able to make contact with several voluntary agencies managed by Americans, and the following Monday I had my first interviews. My procedure was usually thus. I would start: "We know very little in America about the things that happened to you people who were in concentration camps. If you want to help us out, by contributing information about the fate of the displaced person, tell us your personal story. Tell us what is your name, how old you are, and where you were and what happened to you when the war started."

This introduction was usually enough to start a person off on his story, and within less than five minutes he would become oblivious to the microphone before him. The interviews lasted from twenty minutes to four hours, depending upon the readiness of the individual to talk. On only one occasion, when I interviewed the representative of the student body at the international university of UNRRA in Munich, were the sessions limited to about one spool (thirty-eight minutes) per person. As is customary in psychological interviews, I would sit behind the person, so that he would not be influenced by the expression on the face of the interviewer.

Not until a substantial sample of the spools has been transcribed on paper will it be possible to formulate any scientific conclusions from the material. The following lines, therefore, should be taken simply as a travelogue, as a set of notes on the personal impressions gained from about one hundred twenty hours of listening, covering the stories of about seventy people.

It was not the purpose of our expedition to gain a comprehensive picture of the whole problem of the DP's. The project was intended as a psychological and anthropological study by means of a specific tool, the wire-recorder, of the rank and file of DP's. Therefore, any additional knowledge of the general problems was gained incidentally without any inquiry into the statistics of the phenomena.

From material that was supplied to me by UNRRA, and the data gradually pieced together from the interview material, the concentration camp picture was as follows. From the advent of Hitler to power, the rights of the individual in Germany, especially the rights of protection by the courts, were suspended. There were no coroner's inquests or their equivalent, or any other formalities contingent upon the death of an inmate in a concentration camp.

The first contingent for concentration camps were German communists and socialists or people alleged to be such, as well as the outspoken liberals. *These political prisoners speaking the same language as, and often of higher education than, the rank and file of the Gestapo men easily took over the leadership in the camps and managed to occupy nearly all the positions usually allotted to inmates in any place of imprisonment, such as managers of kitchens and warehouses, typists, draftsmen, amusement directors, and trustees in charge of supervision over their fellow-prisoners.

In time there appeared another category of concentration camp inmates, the so-called BV-er (pronounced Befauer) which means a Berufsverbrecher (professional criminal). To the latter category also belonged the sex offenders. These two categories of the concentration camp population became the elite of the lagers (camps) as soon as the other categories began to arrive.

First of all, the *others* were the German Jews. The Jewish radicals and Jewish criminals of German citizenship were separated from the same categories of "Aryan" extraction. Then with the approach of war a search was made for the nationality of the ancestry of the German Jew. All those of whom it could be proved that their ancestors ever arrived from Poland or any other foreign country were ordered to leave Germany as undesirable aliens even though they had lived for generations in Germany, spoke only German, and had imbibed the German culture and made valuable contributions to it. Those unable to leave on short notice were interned.

It would be proper to say at this point that from the capture of the post of chancellor in 1933 to the heaping up of mounds of unburied bodies in Bergen-Belsen in 1945, the Nazis nearly always endeavored to invest all their acts in a cloak of legality and a sort of transcendental justice.

What strikes the hearer of these concentration camp stories is the diabolic logic of events. It appears that the most sinister acts of the Gestapo were serenely planned and backed by a pragmatic justification. In following the naive tales of the DP's whose deeper thought processes seem to have been arrested for the period of concentration camp terror, one is baffled by the methodical consistency which appears to have permeated the Nazi policies.

From the beginning to the end, from the initial pogroms of 1933 to the gas chambers and crematories of Dachau, there was a struggle for the clothing of the crucified. The keynote of the arrests and deportations was loot, a motivation which was intensified by a war economy in which the production of consumer's goods and food for the civilian population was nearly paralyzed. When Austria was annexed and conscription began for the army of the Reich, it became obvious that every drafted soldier was one worker less on the production line and at the same time one more very intensive consumer of food and clothing and war gear. As soon as the Germans entered Vienna, they formed a Jewish Community

* Members of the Christian clergy of German nationality when accused of anti-Nazi ideologies were mostly sent to a special camp (Mònthausen). The best information I have is thaat their number reached about the 500 mark. However, numerous clergymen of the invaded countries were interned on suspicion of connections with the anti-Nazi underground. No recognition of any kind was granted the imprisoned Jewish clergy.

Council. Every so often the Community Council would get instructions to deliver to the railroad station such and such a number of Jews for deportation. Whom should they select? Well, that was for the Council to decide. Suppose they used a *criterion*. Maybe the old, maybe the well-to-do, maybe the rich, maybe the poor.

It was this corruption of the fellow citizens of non-Jewish faith, and at times of the "remaining" Jews, this bribery of the population with loot and spoils taken from the deportees that greatly eased the task of the Nazis. There were of course exceptions. Here is one. In the train from Geneva to Milan, I found myself in a compartment with seven other passengers, among them two women. I was especially attracted by the neat appearance of the older of the two, a gray-haired dowager with somewhat masculine features.

"Excuse me," I said in German, "where did you get these clothes—I mean where were they made?"

The woman looked at me and then responded with a patronizing smile. "These are our old things. When we were deported, we left our better clothes and some of our jewelry with a Christian neighbor, a Czech. The agreement was that she was to wait until the war was over. If the war was lost and we did not return, the things were hers. If the Germans were driven out of Czechoslovakia and we did return, we were to get our things back. Well, she saved and returned everything. This dress and our furs were among them."

Such examples of pure, unselfish decency on the part of Christian neighbors appear time and time again on my records, not only from Czechoslovakia and France, but at times even from Germany.

Unfortunately, the opposite is also true in an overwhelming number of cases. DP's return to their cities of origin and find their homes occupied and the people refusing to restore the property to their owners. To be sure, that happens frequently in bombed-out areas, but it also happened in Paris, and the litigation for the return of such property is often complex and costly.

With Nazi rule it appeared that one step just led to another.. First the Nazis drove Germany into a world war, without a single voluntary ally. The offensive against Russia led through hundreds of miles of hostile territory of Czechoslovakia and Poland. The local population was starving, as a result of destruction of resources by war and looting by invading armies. To alleviate the scarcity, the Germans conceived the monstrous idea of curtailing the population by about five million, i. e., by its Jewish components. There was, however, no technique available for mass-killings in such proportions, nor were there burial facilities available in such quantities at short notice. The slaughter must then go on according to plan and spread over a number of years. Food rations for doomed were reduced to a minimum; that of course led to a desirable high mortality. But the road to the grave by starvation is rarely a direct one. It usually goes by way of infectious desease, and that becomes a threat to the army and the rest of the population. So there occured the idea of segregation into ghettos, from which in turn the selection was made for concentration camps. There were two kinds of camps: labor camps in the vicinity of war plants, and annihilation camps, of which the most notable were Auschwitz, Treblinka, and Bergen-Belsen. There were, however, many other camps of each category separately, or both types combined. District by district the occupied countries were made Jew-clean (Judenrein). The whole Jewish population had to assemble on the city square, families together in groups. A trivial reason would be given for such assemblies such as the restamping of identity cards, and people would come suspecting no harm. They would pass before the commission; the old and the sick, or mothers with small children would go to the annihilation camps. This is group 3. Of course they were not told the truth. They were told that they were being "evacuated from the war zone" or sent where there was "light work" and more food available. Men and women without children from eighteen to thirty-five would go to work camps or to camps with double facilities, annihilation or industrial work. This is group 2. Youngsters from twelve to eighteen remain temporarily at work in local industries, forming group 1, or also join group 2.

Let us listen to a fragment of spool 138. We find there a description (in German) of a typical transport. The interviewee is Jurgen Bassfreund, about twenty years of age, a boy of German birth and education. We give a literal translation of the German text: "The word trickled through that this transport was going to Dachau. We stepped forward, we were given a plate of soup, and, accompanied by S. S., we were sent to the station and were loaded into wagons. They were in part open, in part closed cars. We thought that the closed cars were better, but later it appeared we were worse off. When we were standing at the cars, the S. S. drove us into the cars, one hundred twenty people into each car. It was an impossibility."

Boder: "You were in a closed car?"

Jurgen: "Yes, in a closed car. The doors were shut. We had no food with us, and now we tried to sit down. When eighty people sat down the others had no place to stand, and there were many people who were very tired. It was not possible, otherwise one stood over the other. We stepped on other people's fingers, and these people, of course, resisted and were striking the others, and so a panic began. It was so terrible that people went crazy during the trip, and while we were travelling there appeared among us the first man dead.

"And we did not know where to put the dead—on the floor they were taking up space—because they had to lie stretched out. And then it occured to us—we had a blanket with us so we wrapped the dead man into this blanket, and there were two iron bars in the car, and so we tied him on above."

Boder: "Like in a hammock?"

Jurgen: "Yes, like in a hammock. But soon we understood that that wouldn't do, because we had more and more dead, because of the heat in the car, and the bodies began to smell. And so we were traveling, and there were German troop transports which were retreating from the front because the front was receding, and they had to retreat further. And so all the tracks

were blocked, and we had to stand for days to let the troop transports through first, and at night one could not see a thing. And one was beaten and trampled. In my case my trousers, my prisoner's trousers, were torn lengthwise and I could not wear them any more. And I remained in my underpants. And so without any nourishment, without a drop of water or a piece of bread, in spite of the fact that we yelled for water, and there was snow outside, the S. S. gave us nothing. And we—there was an insane mass of dying people in the car, and after traveling so for five days, we arrived in Regensburg. It was already night, and the S. S. opened the doors and said, 'If you throw out the dead bodies you shall get some food.' And so I and a friend removed twenty-five dead bodies from this car and laid them outside on the snow, you see? And then we were given a piece of bread and a paper beaker of soup. The Red Cross had their feeding point; so we had to line up before the cars, and each was given his ration. Car after car . . . ."

Boder: "Was that the German Red Cross?"

Jurgen: "Yes, that was the German Red Cross. After we had consumed our food, we had to get back into the cars, and so I was in my underpants in the snow. I had no more socks on, and I don't know what the people there may have thought—those nurses (sisters). At any rate we traveled on."

Boder: "Couldn't you get yourself some other pants?"

Jurgen: "No, that was impossible unless I would have taken them from a dead man, but one was too exhausted from the long trip, if one hasn't eaten anything for five days and five nights. I had been standing all the time during the trip, and I saved my life only through that—that I had tied a piece of rope to the car and held on tight. It was really an utter impossibility." And when we arrived in Dachau there were more dead bodies than survivers."

Upon arrival at the concentration camps, the old, the sick, the women with children were sent immediately to the gas chambers (they thought they were going bathing), often to the tune of an orchestra. Those fit to work were shaven wherever there was a hair on the body, and a number was tattooed on their arm; they were dressed in disinfected clothes, not their own, but just picked at random from the disinfecting chamber, and were finally assigned to barracks. It was *logical* that any semblance of order among such masses of hungry, tired and panicky people could not be achieved without recourse to extreme brutality. Murder by clubbing and improvised garroting were common events in such camps.

Meanwhile the bodies from the gas chambers were processed. Gold teeth were extracted, and women's hair was shorn off for industrial use. Then the bodies were burned. There were never enough ovens for cremation, and the bodies were burned in open pits in full view of the prisoners and the neighboring population. Never was there a stethoscope applied to the bodies before cremation, and the common belief is that the quantity of gas allowed was not always sufficient to kill. These are some "moderate" episodes taken from the wire recorder, all confirmed by unsolicited statements of DP's in camps far apart, and well substatiated by the material gathered for the Nurenburg trials. And these are their memories!

We shall devote the rest of the allotted space to brief descriptions of some special groups of the DP's.

THE PIED PIPER

At Bellevue, a suburb of Paris, I found a children's colony with its Pied Piper, Miss Kuchler. This woman, a doctor of philosophy from a Polish university, managed to spend the time of German occupation as governess in the home of a Polish nobleman. She had "black" papers, i. e., forged identity papers, and the princes, appreciating her modest demands, asked no questions.

After the expulsion of the Germans from Poland, it appeared that many Polish families, as well as orphanages maintained by the Catholic convents and monasteries, were sheltering numerous Jewish children, who in this way were saved from Nazi extermination. These children were most often abandoned at the door steps of good-hearted Christians by previous arrangement, sometimes with money or jewelry in payment for their future keep, sometimes just with a note pleading to take the child, "who had been baptised." This latter statement was made often by agreement with prospective foster parents or orphanages to prevent actual baptism of these children. There were also cases where members of the otherwise dreaded Polish militia or even Nazi soldiers would carry out in their knapsacks abandoned infants from the burning ghettos. The Catholic nuns and monks would accept these waifs without questioning and bring them up with the rest of the numerous orphans of war. Now once the enemy was expelled, a revaluation of the future of these children was begun. In rare cases the children were claimed by a surviving parent or relatives. Identification was made by birth marks, pieces of clothing, copies of letters and the like. I possess a wire recording of the story of a woman who identified her child in the fashion of a romantic melodrama, by a gold medallion on the neck of the child from which a fragment was missing, the mother being in possession of that fragment. She carried it on her person, through a string of concentration camps at the risk of her life, since the possession of jewelry and valuables was most severly punished. In many cases the Jewish community began to demand the return of these children; in other cases the convents did not find it proper to force upon children a religion different from that of their parents. The fact that the male foundlings were circumcised may also have affected the decision.

Well, Miss Kuchler found about ten educated men and women of reasonably good health and courage (mostly partisans and not concentration camp victims). She then collected about fifty-three stray children, about twenty of them under six years of age, and the others up to about the age of fourteen. They managed to "steal" the Polish border into Czechoslovakia, and from there were taken on American-made UNRRA trucks to France.

See DISPLACED on page 32

OXYGEN BY THE TON[1]

By J. HENRY RUSHTON

For centuries past man has used the oxygen in air in producing his artifacts. Gradually he learned to separate the oxygen from the nitrogen in air and from the hydrogen in water. These separations were costly and could only be justified where oxygen of high purity was required. The oxygen was used in small quantities by scattered consumers, a fact which made necessary the building of many relatively small manufacturing plants suitably located to reduce transportation costs to market. Oxygen is a highly reactive element and therefore is, theoretically, important as a raw material for industrial and synthetic purposes. Improved processes and equipment for the winning of oxygen from air have been devised within the past few years, and we are at the threshold of an era promising great advances in the more efficient use of oxygen. Where pounds have been used heretofore, tons will shortly be consumed. The term "tonnage oxygen" has been proposed recently to differentiate the production of oxygen in this budding industry from the production in relatively small quantities made in the past.

Oxygen, or oxygen-enriched air, or other oxygen-enriched gases, undoubtedly will be employed on a very large scale for improving processes and products and in the manufacture of new products in the process industries. Potential examples are:

1. For the production of gas from coal by continuous complete gasification for use as city gas of current or increased thermal content.

2. For the production of gas with a composition suitable for synthesizing hydrocarbons, oxygenated products, and ammonia from coal and natural gas.

3. For the oxidation of ammonia and sulphur dioxide and for the partial oxidation of organic compounds to derivatives.

4. For the roasting and burning of sulphide ores, pyrites and other sulphur-containing compounds.

5. For the smelting of iron ores and the refining of iron in Bessemer converters and open hearths.

6. For the combustion of fuels where unusually high temperatures are advantageous, such as calcining and perhaps even for the direct combination of nitrogen and oxygen.

Many other uses will be devised by chemical engineers. Oxygen must be produced in large quantities in the gaseous form by air rectification and piped to its point of use to be sufficiently cheap for these purposes.

ROLE OF OXYGEN

The use of oxygen in concentrations higher than that in air makes possible many favorable chemical and thermal conditions. This is primarily due to the fact that a smaller amount of non-reactive nitrogen is present, and higher temperatures and lower gas volumes result.

In the production of gaseous fuels it is desirable to attain as low a nitrogen content as possible. Gaseous fuels made from coal or coke in gas producers by an air and steam blast contain nitrogen, hydrogen, carbon monoxide, and carbon dioxide, and it is much more difficult to lower the nitrogen content of such a gas after it is manufactured than it is to separate nitrogen from atmospheric oxygen.

Many sulphide ores are available which when roasted with air give flue gases so lean in sulphur dioxide that its recovery is difficult or uneconomical. Oxygen-enrichment of furnace blast can be used with such ores to increase the sulphur dioxide concentration to seven per cent or more, which is in the range of usual sulphur dioxide recovery or conversion operations. Lean sulphide ores which will not support their own combustion in air can be made to react with oxygen or enriched air without the necessity of supplying solid, gaseous, or liquid fuel to maintain combustion and operating temperatures.

Sulphur dioxide, or other gases made by the use of pure oxygen or enriched air, permits the use of equipment of minimum size for absorption or conversion to other products.

During ore reduction in blast furnaces using coke, it is possible to increase the concentration of carbon monoxide — the principal reducing agent—by the use of oxygen. The amount of carbon monoxide is dependent upon both the concentration of the reactants and the temperature. The higher temperature resulting from higher oxygen concentrations favors the dissociation of carbon dioxide, with the result that carbon monoxide concentration increases more rapidly than does carbon dioxide concentration when higher temperatures are used. Thus, by the variation of oxygen concentration, control of carbon monoxide and temperature can be effected. Furthermore, freezing and hangups in the furnace can be eliminated immediately by changing the oxygen percentage of the blast.

Flame temperatures are sensitive to oxygen concentration and to the total amount of product gas. As oxygen concentration increases, the flame temperatures increase because of more rapid combustion rates and also because less inert nitrogen is present in the hot combustion products. Combustion time is shortened and flame length is shortened by increased oxygen, with the result that smaller combustion spaces are required. In furnace operations where combustion flames are used to radiate heat to molten reactants, as in reverberatory furnaces, the rates of heat transfer are increased by increasing flame temperatures. Radiant heat transfer is proportional to the difference between the fourth powers of the absolute temperatures. Thus a small increase in flame temperature has a relatively large effect on the rates at which heat passes

[1] A condensation of an article titled "Tonnage Oxygen," by C. R. Downs and J. H. Rushton, appearing in *Chemical Engineering Progress*, Jan., 1947.

from the flame to the surroundings.

Wherever high flame temperatures are beneficial, as in melting, smelting, calcining, and roasting operations, the processes can be speeded to any desired rate by oxygen enrichment, thereby increasing furnace capacity. Moreover, temperatures can be controlled at will by varying the per cent of oxygen enrichment.

The advantages of the use of oxygen as just outlined have long been recognized, but heretofore the advantages have been outweighed by the high cost of oxygen.

PRODUCTION OF OXYGEN

Air liquefaction and rectification is the basic process considered most suitable for large-scale oxygen production. Tonnage oxygen for process use need not be of the purity required for cutting and welding of metals. For large tonnage industrial uses a purity of about 97 per cent is considered suitable. The development of low-pressure processes for producing gaseous, relatively pure oxygen have been developed in recent years in Germany, and during the war by the National Defense Research Committee, Office of Scientific Research and Development, in this country. The objective of most recent improvements has been to devise systems to utilize low-pressure, high-capacity, high-speed compression and refrigeration equipment, and to remove carbon dioxide and water efficiently from low-pressure air. The prevention of acetylene accumulation in the systems has received important consideration.

It is obvious that the extent to which oxygen will be used in industry will depend upon the cost of oxygen plants and upon their operating costs. These costs per ton of oxygen are dependent largely upon the size of units. Units producing less than 5 tons of gaseous oxygen/hr. (120 tons per day) are about the lower economic limit of capacity for the uses here considered. Such a size, however, satisfies many uses. The cost of producing oxygen in smaller units rises rapidly and debars its economic use for many otherwise attractive applications; it limits its use to cutting, welding and similar operations.

Table 1 gives estimated plant and operating costs as of January 1, 1947, for various sized oxygen producing units. These costs include engineering design, equipment, erection, buildings, water cooling towers and all other parts to make a complete turn-key installation with utilities furnished at the site. Production is based on 346 operating days per year; and "on stream" factor of 0.95.

GAS PRODUCTION FROM COAL

The complete gasification of coal, with maximum retention of its heat in the gas, has long been a goal of the gas industry.

Water gas is made by the reaction of steam with incandescent coal or coke, and is the basis of most of the city gas of today. The alternate admission of air and steam is used in cyclical fashion, and the water gas consisting of carbon monoxide and hydrogen is collected alternately. The thermal or available B.t.u. content of water gas (around 300/B.t.u. cu. ft.) is too low to meet statutory requirements, and it is necessary to add natural gas or petroleum refinery gases, or to carburet it with oil. It is evident that these processes do not permit maximum conversion of the potential heat energy in the solid fuel to heat energy in the gaseous fuel, because large quantities of carbon are converted to carbon dioxide in the process and wasted along with the nitrogen.

Continuous and complete gasification of coal or coke can, however, be accomplished at high thermal efficiencies when oxygen is employed. Temperatures of the fuel necessary to obtain reaction with steam can be achieved by using high-purity oxygen, injecting it into the fuel bed along with the steam. And the exothermic heat

Table 1—Estimated Plant Costs And Operating Charges, January, 1947, For Producing 95 Per Cent Oxygen

Plant Capacity:					
Tons/day	120	240	360	480	1,000
Tons/hr.	5	10	15	20	42
Approximate plant cost	$900,000	$1,300,000	$1,700,000	$2,000,000	$3,400,000
Total utiilty cost/ton*	$1.29	$1.27	$1.25	$1.22	$1.20
Operating labor/ton†	0.68	0.34	0.23	0.17	0.08
Maintenance/ton‡	0.54	0.39	0.34	0.30	0.25
Fixed charges/ton§	2.70	1.95	1.70	1.50	1.22
Total operating cost/ton	$5.21	$3.95	$3.52	$3.19	$2.75
Total operating cost/M cu. ft.	21.7c	16.5c	14.7c	13.3c	11.5c
Kw. hr./per M cu. ft. for compression	13.4	13.1	12.8	12.7	12.5
Kw. hr./M cu. ft. for auxiliaries	2.2	2.2	2.2	2.2	2.2
Total kw. hr./M cu. ft.	15.6	15.3	15.0	14.9	14.7

* This figure includes charges for a negligible amount of make up water at 1 cent/1,000 gal., electric power for pumps, cooling towers and auxiliaries at 0.4 cents/kw. hr. and steam for heat and principal source of power at 30 cents/1,000 lb.

† Operating labor is taken at $80/day including labor overhead.

‡ 2½ per cent of plant cost.

§ 12½ per cent of plant cost.

of reaction of carbon with oxygen can be made to balance the heat required to maintain the carbon-steam reaction. From such an operation, a gas results consisting essentially of carbon monoxide and hydrogen, the relative amounts depending on the feed ratio of oxygen and steam and the temperature and pressure of the operation.

For the past twelve years processes have been in operation in Germany for the manufacture of city gas by continuous processes using oxygen.

Several plants have been tested in the United States and Canada to demonstrate the feasibility of the processes, but the processes have not been adopted by the utilities largely because of lack of large-scale oxygen production units.

The first German plant to produce city gas from brown coal was put into operation for city supply in 1936. Subsequently a number of other plants were installed. At Bohlen, Germany, a complete plant of ten units with a capacity of 20 million cu. ft./day delivers a purified gas of 455 B.t.u. Reports are that the most recent plant at Most, Czechoslovakia, is operating now at 20 atm. pressure and producing about 15 million cu. ft. of 570 B.t.u. city gas/day. The washed gas is under pressure suitable for long-distance transportation without further compression.

It is reported that in Russia fuel gas is being produced by subterranean reaction of coal with oxygen, or oxygen-enriched air, and steam. The process does not look attractive for use in the United States, although plans are now in preparation for a trial of this process in Alabama. Russian plans are for the production by this method of more than 32 billion cu. ft. of gas/yr. by 1950.

The use of oxygen for city-gas generation is potentially large but cannot be considered economical unless used for large base loads. The capital investment in oxygen equipment makes it imperative that it be used continuously. The processes should not be considered as the means of taking care of high-peak loads because this would postulate considerable idle time for expensive equipment.

SYNTHESIS GAS PRODUCTION

Synthesis gas is produced for a variety of purposes each requiring a particular composition, for which many different processes are used.

A synthesis gas for ammonia production must contain nitrogen and hydrogen in approximately stoichiometric proportions. In the past this has been accomplished by using the water-gas process modified to give the desired composition. Or it is produced often from natural gas. Air suitably enriched with oxygen can be used advantageously with steam either solid or gaseous fuels to give continuous production of ammonia synthesis gas.

Synthesis gases for production of organic compounds consist of mixtures of carbon monoxide and hydrogen in various proportions. These gases then are converted catalytically to the organic compounds by several processes depending upon the objectives.

Synthetic methyl and higher alcohols have been in commercial production for many years. More recently, processes referred to broadly as Fischer-Tropsch syntheses have been developed. The basic reactions involve the passage of carbon monoxide and hydrogen (and sometimes with added olefines) over various catalysts at different pressures and temperatures.

The so-called "Kogasin" synthesis uses carbon monoxide and hydrogen in a ratio of 1 to 2 over iron cobalt and nickel catalysts at atmospheric pressure and 480 to 570° F. to produce essentially a hydrocarbon product. Equation (1) represents the theoretical reaction:

$$nCO + 2nH_2 \rightarrow (CH_2)_n + nH_2O \quad (1)$$

Variation of the ratio of carbon monoxide to hydrogen affects the end product for a given catalyst. In general the increase of carbon monoxide favors the production of olefins.

The "Synthine" process is a name which is apparently being accepted in the United States, in lieu of Fischer-Tropsch, to make products which are mixtures of hydrocarbons and oxygenated products. These hydrocarbons comprise the synthetic diesel and automotive fuels.

Carbon monoxide and hydrogen are used also together with the higher olefins, C_{11} to C_{17}, to make higher alcohols which can then be converted to soaps.

The synthesis gas required for the reactions above can be prepared directly from natural gas by the use of oxygen, or from solid fuels by the use of oxygen and steam. From natural gas by partial oxidation, the principal exothermic reaction is:

$$CH_4 + \tfrac{1}{2}O_2 \rightarrow CO + 2H_2 \quad (2)$$

Here the ratio of 1 carbon monoxide to 2 hydrogen can be produced directly, and it is possible to vary the ratio by suitable control of operating conditions. Also the reaction can be modified and controlled by the use of steam for quenching or for reacting with methane. Synthesis gas for ammonia may be made by substituting air or oxygen-enriched air for the oxygen, removing the oxides of carbon which are formed, and hydrogen and nitrogen remain in desired ratio.

The 7,000 bbl./day Synthine plant (5,800 bbl. gasoline and 1,200 bbl. Diesel oil) as projected for Brownsville, Texas, will require at present design, about 45 million cu. ft. of oxygen/day and about 64 million cu. ft. of natural gas. When the natural gas contains inerts, such as nitrogen, a proportionally greater volume must be used.

From solid fuels the water-gas reaction in solid-bed producers can be made continuous by the use of oxygen and steam. A variation of pressure can be used to change the ratio of carbon monoxide to hydrogen.

CONVERSION OF NATURAL GAS INTO LIQUID FUELS

The first raw material to be used for making synthetic gasoline and other liquid fuels in the U. S. will be natural gas. The first Fischer-Tropsch process was put into commercial operation at Oberhausen, Germany, in 1936. Brown coal or coke was the raw material.

The known reserves of natural gas in 1945 were 140 trillion cu. ft., compared with 100 trillion cu. ft. in 1940. This shows a 40 per cent increase in natural gas reserves during a period in which our known petroleum reserves remained unchanged. This increase has been due to more active

exploration for gas and to re-evaluation of gas fields, and indicates that our gas reserves are likely to be much more than the estimates indicate.

It has been stated that the 1945 known gas reserves, if all converted into liquid fuels, would be enough to double our known reserves of petroleum. Much of this gas is scattered in small fields or enjoys a higher value for other purposes which prevents its use for the Synthine process. Five fields, however, contain 40 per cent of the total estimated reserves and it is only these fields which will support Synthine installations.

As economic conditions change, the process as developed for using natural gas can be modified to use coal, of which there is plenty to last into the distant future. It is agreed generally that coal will not be used for this purpose where natural gas is abundant.

The over-all cost of producing gasoline and Diesel oil from natural gas at 5 cents/1,000 cu. ft. by the Synthine process is stated to make them competitive with these products produced from petroleum. The Brownsville installation referred to above is expected to make approximately 2,000 tons of oxygen/day in two units each rated at 42 tons of oxygen/hr. The output of a unit of this magnitude is vastly greater than any attained in the past. At the time this paper is being written other installations are being planned, for example, one by the Standard Oil Co. of Indiana in the Hugoton field in Kansas and another by Humble Oil and Refining Co. at a location not publicly announced. These plants are expected to be at least as large as that at Brownsville.

Despite the fact that it is much too early to predict how many Synthine plants will be built, estimates have been made that in the long-term future there may be from thirty to seventy units of the 7,000 bbl./day size, or their equivalent in larger sizes. They may include plants using low-rank coals for making the synthesis gas. These installations would produce from 10 per cent to 25 per cent of the present production of motor fuels and light naphthas. The lower estimate is probably much more realistic. Whether such a forecast is accurate or not, it presents a rough picture at least of the enormous quantities of oxygen that may be required.

The yield of oxygenated by-products may vary from a small percentage of the liquid hydrocarbons to very high percentages. It has been reported that these ratios, operating on natural gas as a raw material, may vary from about 10 per cent to as much as 30 per cent. The production of aldehydes, ketones, alcohols and acids that can be expected to be produced annually from a single 7,000 bbl./day Synthine installation are estimated approximately as follows:

Total aldehydes and ketones
34 million lb./yr.
Total alcohols
85 million lb./yr.
Total acids
41 million lb./yr.
Total oxygenated by-products
160 million lb./yr.

It must be considered that such large quantities have serious long-term portents for the established industries now producing similar products.

SULPHURIC ACID AND SULPHUR DIOXIDE

Interesting possibilities for the use of oxygen in the production of sulphur dioxide and sulphuric acid should be mentioned. Sulphur dioxide not only has uses by itself and in water solution, but also it is the raw-gas material for all sulphuric acid manufacture.

The use of oxygen in acid manufacture is not new. Pyrites burners are operating now with oxygen-enrichment on the American continent, and it is reported that some use is being made on a large scale in Russia. It is of interest to note the calculated amount (based on data from several sources) of 95 per cent oxygen required to increase the capacity of a 50-ton/day sulphuric acid plant by means of oxygen-enrichment. Table 2 summarizes these estimates. To double the output of acid from a relatively small plant of 50 tons/day would require about 1.5 tons/hr. of oxygen. This is a small amount of oxygen for very low-cost production, but larger acid plants would utilize oxygen at the higher rates necessary to achieve low oxygen costs.

BURNING PYRITES

Large amounts of pyrites, both as ores, and as concentrates from copper, zinc, and gold-winning operations are not now being processed. Some of these ores are in remote places where water power is available but where coal and coke, for reduction of the ore, are at great distances and thus are expensive. Also some of the ores are not rich enough in sulphur and require additional fuel or oxygen-enrichment for reduction operations. Very substantial amounts of concentrated iron pyrites tailings are being discarded at some mining operations, where it is not feasible now with exisiting processes to recover the iron and sulphur from them.

The use of oxygen may be the answer to the problem of utilizing these ores, by providing the basis for solving the critical economics involved.

Large-scale use of oxygen is involved in such operations, but it is difficult to predict oxygen production costs without study of individual projects. Ambient temperatures, water supply, power cost and availability are of prime consideration for locations in very cold climate or in desert areas. As shown previously, oxygen production costs are highly dependent upon such conditions.

Table 2—Approximate Amount Of 95 Per Cent Oxygen Required To Increase Capacity Of a 50-Ton/Day Sulphuric Acid Plant By Oxygen-Enriched Air

		Tons 95 Per Cent O_2/day	
Per Cent Increase H_2SO_4 Capacity	Tons H_2SO_4 /day	Chamber Plant Burning Pyrite	Contact Plant Burning Sulphur
0	50	0	0
10	55	5	4
20	60	10	8
50	75	27	22
80	90	35.5	29
100	100	37.5	31

NONFERROUS METALLURGICAL USES

From an economic standpoint the use of oxygen-enriched air for nonferrous ore reduction operations is very attractive. Of prime interest are smelting operations involving copper, nickel, zinc, and lead ores. The beneficial effects of oxygen arise mainly from the higher temperatures attainable with oxygen-enriched air, and the possibility of maintaining reactions which would otherwise require additional fuel. High temperature is beneficial not only to increase reaction rate but also to allow the use of fluxes to form higher melting-point slags which now cannot be handled in air-supplied operations. New fluxing materials well may allow better control of reduction operations and result in better metal recovery.

Research has been carried on involving the use of oxygen-enriched air on fluidized low-grade sulphide ores, and operations have been carried out using oxygen-enrichment in Herreschoff burners, both here and abroad. Few pilot-plant data are as yet available to indicate clearly the extent of oxygen-enrichment required for the most economical operation. Enrichment of oxygen to at least 26 per cent seems likely and perhaps greater concentrations will prove useful. Copper matte requires large amounts of air in present-day converters. Oxygen is applicable to reduce the quantity of air for such operations, and to increase the capacity of equipment now in use.

It has been estimated that cheap oxygen would reduce markedly the operating costs in the winning of nickel from nickel sulphide ores. There are, however, no published data available on any experimental work in this field. Oxygen would be applied for the same reasons as outlined for copper.

One company at Trail, B. C., has been using oxygen enrichment for the past few years for roasting of zinc sulphide concentrates in Herreschoff furnaces. Estimates indicate that in North America there are more than one million tons of zinc produced per year. This would indicate a large potential use for oxygen.

Lead sulphide ores likewise offer possibilities for extensixe exploitation of oxygen. Low-grade ores not now profitably smelted may well become important if low-cost oxygen can be applied successfully.

IRON AND STEEL APPLICATIONS

Oxygen promises great economic advantages in the operation of pig-iron blast furnaces, Bessemer converters and open hearths. Oxygen has been used in the steel industry in quantities heretofore considered large for such purposes as cutting and welding and for scarfing of billets. But these quantities are small compared to the use of oxygen in the furnaces.

The early work on the use of oxygen in blast furnaces was done in Germany. Oxygen of about 95-98 per cent strength was made for this purpose by the Linde-Frankl process. It was used to enrich air from the 21 per cent normal oxygen content to 26 per cent. Such mild enrichment required no changes in furnace structures or refractories. Somewhat higher percentages of oxygen up to 20 per cent have been reported in the German literature for ferromanganese blast furnaces.

Russian reports indicate that the experimental work conducted there in recent years has been directed toward a much larger scale than in Germany

The enrichment of air to 26 per cent oxygen appears at first sight to be of small extent, but the blowing engines deliver enormous amounts of blast to the furnaces and there are many of them. For example, a survey made last year showed that there were 255 pig-iron blast furnaces in operation in the U. S. The total capacity was approximately 68 million tons annually. The average amount of air at 60°F and 30 in. Hg would be about 67 cu. ft./min./net ton of pig iron produced per day.

Table 3 arbitrarily classifies the 255 furnaces in groups according to net tonnage rated capacity and shows the calculated average cubic feet of air used per minute and the average cubic feet of 95 per cent oxygen required to enrich the blast to 26 per cent oxygen assuming no increase in the volume of the blast.

If all of the 255 furnaces were equipped with apparatus to make 95 per cent oxygen and to enrich the blast to 26 per cent oxygen, there would be required almost 900,000 cu. ft. of 95 per cent oxygen/min. or somewhat more than 2,200 tons/hr. Thus the term "tonnage oxygen" again is a happy choice. Of course, no one expects that all blast furnaces will be so equipped but even a relatively small number of furnaces would consume tremendous quantities of oxygen. Then again the above figures are based upon increasing the oxygen content only 5 per cent, from 21 per cent to 26 per cent, whereas an additional 5 per cent appears to be possible with little change in the furnace structure. Higher percentages undoubtedly

See OXYGEN on page 62

Table 3—Estimates, Potential Use Of Oxygen In U. S. Blast Furnaces, For Enrichment Of Air To 26 Per Cent Oxygen

Rated Daily Net Tonnage	Number of Furnaces	Av. Cu. Ft. of Air at 60° F. and 30-in. Hg./Min./Furnace	Av. Cu. Ft./Min. of Added 95 Per Cent O_2	Av. Total Cu. Ft./Min. of 95 Per Cent O_2 for All Furnaces	Tons O_2 per hour
Below 200	13	$>$13,100	$>$ 900	± 9,100	23
200-300	4	16,800	1,140	4,560	11
300-400	3	23,500	1,590	5,770	14
400-500	15	30,200	2,050	30,750	77
500-600	25	36,900	2,500	62,500	156
600-700	43	43,600	2,960	127,280	318
700-800	48	50,300	3,410	163,680	408
800-900	35	57,000	3,870	135,450	338
900-1000	14	63,700	4,320	60,480	151
1000-1100	17	70,400	4,770	81,090	202
1100-1200	24	77,100	5,220	125,280	313
1200-1400	14	87,100	5,900	82,600	205
	255			888,470	

The Education Of Engineers For Latin America

By L. E. GRINTER

This article will be published in Spanish for distribution in Latin America.

An experience with Latin American students extending over nearly twenty years leads me to venture an opinion as to the kind of engineering or technological education that would lead the Latin American countries into the forefront of industrialized nations. The thoughts expressed here have developed through personal observation of the educational systems of Mexico, France, England and the United States of America and through contact with students from nearly all of the Latin American countries as well as those of Europe and Asia.

Wherever European educational methods have been transplanted to other countries, particularly the educational methods of France and England, we find great emphasis upon the philosophical, cultural and theoretical aspects of technological education with less emphasis upon the laboratory and the practical side of engineering. Moreover, such European systems have carried with them the concept that university education is inherently limited to those of exceptional abilities who naturally form a very small percentage of the population. These two concepts form a natural limitation upon the number and the kinds of engineers in many countries.

We may generalize by saying that in common with most other countries which have followed the European system of education, Latin America has an insufficient number of engineers but that those in practice represent largely the select minds capable of using the most abstract and difficult mathematical theories. For rapid industrialization several times as many engineers will certainly be needed. And it is also clear that most of these additional engineers ought to be trained not so completely in basic theory but more completely in the practical matters of laboratory and pilot plant experimentation and in the techniques of design, construction, and production.

It is useful to compare in broad terms the engineering educational system of the United States with those of England, France, or Latin America. In the United States most of our energies have been devoted to mass education of average students. In the other countries considered here, much more emphasis has been given to the education of superior students. Clearly a well rounded educational system would perform both of these educational services. In the United States we must find a way of giving more attention to the engineering student of exceptional ability who will become the designer, with capacity for invention, or the research man. In Latin America it seems to me that the immediate need is for additional numbers of engineers trained as practical men to carry out the functions of standardized or routine design, construction, operation and production.

For comparison with the training of engineers in each country of Latin America the following statistics should be of interest. In the United States the number of engineering students in the colleges increased from about 70,000 in 1936 to 110,000 in 1941. Then, of course, the War influence reduced the number to 35,000 by 1944. It is most significant however that in the fall of 1946 nearly 225,000 young men in the United States were engaged in the study of engineering as full-time college students. Recently while in England I was told that fewer than 5000 young men were studying engineering as resident students in the universities of that country.

It seems self evident that industrialization can only develop rapidly or to its full flowering when engineers are available in adequate numbers. Some skeptics have doubted that the large numbers of engineers trained in the United States could find proper employment here. Our experience has shown however that industrialization progresses as rapidly as the engineers can be educated who are required to lead the way.

It seems likely that the drastic requirements for successful engineering study, which include mathematical ability, a practical sense of values and capacity for making decisions, will always restrict the number of qualified engineers below the number that could be used effectively. Those with lesser abilities will naturally fill subordinate positions as engineering assistants. It seems unwise for any country to provide inadequate educational facilities in the engineering field when its competitive existence in the future may well depend upon the quality and the numbers of its engineers.

MIDWEST POWER CONFERENCE
PRELIMINARY PROGRAM

March 31, April 1-2, 1947

Palmer House, Chicago

The Midwest Power Conference was reorganized in 1938 as a cooperative institution with university and technical society associations. The major responsibility and sponsorship has been centered in Illinois Institute of Technology which operates the conference with the cooperation of the mid-western universities and the local and national societies listed on the cover.

The purpose of the Power Conference has been established as that of offering an opportunity for all persons interested in power production, transmission or consumption to meet together annually for the study of mutual problems free from the restrictions of required memberships in technical or social organizations. Academic sponsorship should permit the freest possible discussion ranging from the technical through the economic and into the social aspects of the subject. Invitations are extended to all persons interested in the Nation's power problems.

University Representatives

M. P. CLEGHORN
Iowa State College

W. A. LEWIS
Illinois Institute of Technology

D. D. EWING
Purdue University

L. G. MILLER
Michigan State College

J. S. GAULT
University of Michigan

N. A. PARKER
University of Illinois

E. W. KIMBARK
Northwestern University

R. E. SUMMERS
University of Minnesota

E. B. KURTZ
State University of Iowa

M. O. WITHEY
University of Wisconsin

Monday, March 31, 1947

9:00 A. M. Registration, Palmer House.

10:15 A. M. Opening Meeting. Chairman: W. A. Lewis, Illinois Institute of Technology.

(a) Address of Welcome. M. O. Withey, Dean, College of Engineering, University of Wisconsin.

(b) Trends in Electric Power Supply. Colonel H. S. Bennion, Managing Director, Edison Electric Institute, New York.

(c) The Economic Situation of the Present, and What It Presages for the Future. Pearce Davis, Director, Dept. of Business and Economics, Illinois Institute of Technology.

(d) Depreciation Rates. Robley Winfrey, Research Professor of Engineering Valuation, Iowa State College.

12:15 P. M. Joint Luncheon with A.S.M.E. Chairman: B. H. Jennings, Chairman, Chicago Section, A.S.M.E.

Speaker: Arrangements pending.

2:00 P. M. Central Station Practice. Chairman: D. G. Reid, Chairman, Power & Fuels Div., Chicago Section, A.S.M.E.

(Sponsored and arranged by the Power and Fuels Div., Chicago Section, A.S.M.E.)

(a) Central Station Combustion Control Problems. C. H. Smoot, Republic Flow Meters Co., Chicago.

(b) Inspection for Safety Power Plant Equipment. Wm. D. Halsey, Chief Engineer, Boiler Div., Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn.

(c) Discussion.

2:00 P. M. Developments in Heating. Chairman: Oliver J. Prentice, C. A. Dunham Co., Chicago.

(a) Panel Heating with Air. H. F. Randolph, Vice President, International Heater Co., Utica, N. Y.

(b) Baseboard Radiation Developments. W. S. Harris, Dept. of Mechanical Engineering, University of Illinois.

(c) Losses in the Cycle of a Heat Pump Using a Ground Coil. R. A. Budenholzer, Armour Research Foundation of the Illinois Institute of Technology.

(d) Discussion.

3:45 P. M. Diesel Power. Chairman: R. E. Summers, University of Minnesota.

(a) Diesel Developments of Significance. C. G. A. Rosen, Director of Research, Caterpillar Tractor Co., Peoria, Ill.

(b) The Performance of the Diesel Locomotive, A. G. Hoppe, General Supt., Locomotive and Car Depts., Chicago, Milwaukee, St. Paul, & Pacific R. R. Co., Milwaukee.

(c) Discussion.

3:45 P. M. Power Supply for Fluctuating Loads. Chairman: E. W. Kimbark, Northwestern University.

(a) Power Supply to Fluctuating Loads on a 4000-Volt Distribution System. H. E. Smith, Distribution Planning Engineer, Commonwealth Edison Co., Chicago.

(b) Industrial Plant Power Distribution System. C. W. Wright, Electrical Engineer, Delco Products Div., General Motors Corp., Dayton, Ohio.

(c) Discussion.

Tuesday, April 1, 1947

9:00 A. M. Power System Loads. Chairman: D. D. Ewing, Purdue University.

(a) Load Statistics of the Electric Light and Power Industry. George L. Jorgensen, Statistician, Commonwealth Edison Co., Chicago.

(b) Lighting as a Distribution System Load. O. A. Hill, Jr., Public Service Co. of Northern Illinois, Maywood, Ill.

(c) Discussion.

9:00 A. M. Developments in Air Conditioning. Chairman: William Goodman, Illinois Institute of Technology.

(a) Compressors for Air Conditioning. A. B. Newton, Chief Engineer, Airtemp Div., Chrysler Corp., Dayton, Ohio.

(b) Postwar Air Conditioning Advances. John Hertzler, Vice President, York Corp., York, Pa.

(c) Discussion.

10:30 A.M. Hydro Power No. 1. Chairman: F. M. Dawson, State University of Iowa.

(a) Keokuk Hydro—A Third of a Century Old. P. L. Mercer, Plant Manager, Union Electric Power Co., Keokuk, Iowa.

(b) Coordination of Hydro and Steam Power in the Missouri Basin. E. Robert de Luccia, Chief, Bureau of Power, Federal Power Commission, Washington, D. C.

(c) Discussion.

10:30 A. M. Fuels and Combustion. Chairman: N. A. Parker, University of Illinois.

(a) Energy Sources of Tomorrow. Ralph A. Sherman, Supervisor, Fuels Div., Battelle Memorial Institute, Columbus, Ohio.

(b) Methods of Firing Pulverized Coal. (Illustrated by colored motion pictures.) Otto de Lorenzi, Director of Education, Combustion Engineering Co., New York.

(c) Discussion.

12:15 P. M. Joint Luncheon with A.I.E.E. Chairman: L. R. Janes, Chairman, Chicago Section, A.I.E.E.

Speaker: W. C. Johnson, Vice President, Allis-Chalmers Manufacturing Co., Milwaukee.

2:00 P. M. Power Cables. Chairman: P. B. Garrett, Chairman, Power Group, Chicago Section, A.I.E.E.

(Sponsored and arranged by the Power Group, Chicago Section, A.I.E.E.)

(a) Aerial Cables for Electric Distribution. George H. Landis, Electrical Distribution Manager, Central Hudson Gas and Electric Corp., Poughkeepsie, New York.

(b) Corrosion of Underground Cable Sheaths Due to Local Cells. L. F. Greve, Commonwealth Edison Co., Chicago.

(c) Discussion.

2:00 P. M. Small Power Plants. Chairman: M. P. Cleghorn, Iowa State College.

(a) Power for the Paper Industry. Robert Krause, Ass't Plant Manager, Container Corporation of America, Chicago.

(b) Reduction of Air Pollution from Small Boiler Plants. Parker A. Moe, Gates, Moe & Weiss, Engineers, Milwaukee.

(c) Discussion.

3:30 P. M. Electronics in Industry No. 1. Chairman: L. T. Rader, Illinois Institute of Technology.

(a) Good and Bad Electronic Heating Applications in the Wood Industry. John M. Cage, Manager, Industrial Electronics Div., Raytheon Manufacturing Co., Waltham, Mass.

(b) Latest Developments in Electronic Control. W. D. Cockrell, Industrial Engineering Div., General Electric Co., Schenectady.

(c) Discussion.

6:45 P. M. "All Engineers" Dinner. Informal. Grand Ball Room. (Ladies Invited.)

Toastmaster: James D. Cunningham, President, Republic Flow Meters Company, Chicago.

Speaker: Richard R. Deupree, Executive Chairman, Army & Navy Munitions Board, Washington, D. C., and President, The Procter & Gamble Company, Cincinnati, Ohio.

Wednesday, April 2, 1947

9:00 A. M. Metallurgy of Power Plants. Chairman: Otto Zmeskal, Illinois Institute of Technology.

(a) Metallurgical Considerations in H.T.-H.P. Piping Layouts. J. J. Kanter, Materials Research Engineer, Crane Co., Chicago.

(b) Materials as a Consideration in Modern Boiler Feed-Pump Construction. Hugh Ross, Chief Engineer, Centrifugal Pump Dept., Allis-Chalmers Manufacturing Co., Milwaukee.

(c) Discussion.

9:00 A. M. Electronics in Industry No. 2. Chairman: E. B. Kurtz, State University of Iowa.

(a) Electronics in Power and Process Instrumentation and Control. C. H. Barnard, Application Engineer, Bailey Meter Co., Cleveland.

(b) Power Line Carrier Current Equipment. R. C. Cheek, Central Station Division, Westinghouse Electric Corp., East Pittsburgh.

(c) Discussion.

10:30 A.M. Hydro Power No. 2. Chairman: Ben Elliott, University of Wisconsin.

(a) Correlation of Hydro-Plant and Steam-Plant Operation. Vincent Thieman, Wisconsin Public Service Corp., Green Bay, Wis.

(b) Discussion.

10:30 A. M. Feedwater Treatment. Chairman: L. G. Miller, Michigan State College.

(a) Demineralized Water. Lyle B. Porter, Director of Research, Illinois Water Treatment Co., Rockford, Ill.

(b) Removal of Carbon Dioxide from Alkaline Waters. Arthur E. Kittredge, Vice President and Chief Engineer, Cochrane Corp., Philadelphia.

(c) Discussion.

12:15 P. M. Joint Luncheon with W.S.E. Chairman: Titus G. LeClair, President, Western Society of Engineers.

Speaker: Preston T. Tucker, President, Tucker Corporation, Chicago.

2:00 P. M. General Session. Chairman: Herman Halperin, Chairman, Civic Committee, Western Society of Engineers.

(Sponsored and arranged by the W.S.E.)

Subject: Increasing the Engineers' Contribution to Civic Progress.

Speakers:

Mayor Edward J. Kelly, City of Chicago;

R. M. Gates, President, Air Preheater Corp., New York;

Joseph D. Lohman, Lecturer in Sociology, University of Chicago, and Director of Race Relations, Julius Rosenwald Fund.

3:30 P. M. Gas Turbines: Chairman: John T. Rettaliata, Illinois Institute of Technology.

(a) Where Will the Gas Turbine Fit as a Stationary Power Plant? L. N. Rowley, Managing Editor, and B. G. A. Skrotzki, Associate Editor, *Power*, New York.

(b) Recent Gas Turbine Developments at Brown-Boveri. Paul R. Sidler, President, Brown-Boveri Corp., New York.

(c) The Coal-Burning Gas Turbine Power Plant. John I. Yellott, Director of Research, Locomotive Development Committee, Baltimore.

(d) Discussion.

3:30 P. M. Transmission and Distribution. Chairman: J. S. Gault, University of Michigan.

(a) Unit Substations for Distribution Systems. R. L. Witzke, Central Station Engineer, Westinghouse Electric Corp., East Pittsburgh.

(b) Six-Year Operating Record of Transmission Lines Designed for Improved Performance Under Lightning Conditions. E. W. Oesterreich, Superintendent of Distribution, Duquesne Light Co., Pittsburgh.

(c) Electric Power — Its Relation to National Security. John W. Swaren, Research Analyst, Industrial College of the Armed Forces, Washington, D. C.

(d) Discussion.

DISPLACED

(Continued from Page 21)

Hardly any of these children know anything about relations living: at least that is the claim. Where are they expected to go? The answer is one word *"Eretz"* which translated: *"The Land,"* and means *Palestine.*

BUCHENWALD CHILDREN

A group by itself is the so-called "Buchenwald children." Buchenwald was a large concentration camp near Weimar, the city of Goethe and the birthplace of the Weimar Republic. Here the Germans concentrated prisoners evacuated from other camps who managed to survive the death marches in the winter blizzards of 1944-1945. When the American tanks entered Buchenwald, they found among the many thousand prisoners of all nations and creeds, an estimated one thousand youngsters in their teens emaciated from starvation, ridden with disease, and covered with lice. Blood transfusions, continuous feeding, medical care, and encouraging friendly companionship of the army chaplains, Red Cross and UNRRA personnel nursed many of them back to life. Many of them died after liberation.

Switzerland agreed to accept a number of them. Others were taken to France. Some of them distrusted everybody and went roaming through the countryside, begging and stealing, attaching themselves to American and English military units. Some of these youngsters barely knew their given names. Some of them know that there is an Uncle Charley in Detroit and an Uncle Jake in California, but what are their last names? These youngsters are being trained in modern trade schools organized by charity organizations such as the ORT or the OSE, the funds for which come from all North and South America, France, South Africa, and local sources. These are modern schools with modern equipment and teachers of the highest technical and pedagogical standings.

DP'S OF CHRISTIAN FAITHS

By the middle of September I got my clearance for Germany under the auspices of the UNRRA, with complete freedom of movement, unrestricted selection of human samples, and no attempt at cenorship of the collected material. Only here did I obtain a broad view of the problem of the displaced persons. According to latest reports, there are in the American Zone about 500,000 DP's of whom only about 125,000 are Jews. The rest are Letts, Latvians, Estonians, Balkans, and Poles. There are also a few thousand Mennonites who came from the Russian Ukraine.

THE BALTICS

These are the Estonians, Latvians, and Lithuanians. After the short-lived Russo-German agreement, Soviet Russia acquired the right to construct bases in the Baltic states. With this there began a movement for the reincorporation of the Baltic states into Russia, from which they were separated after World War I. Then the Germans came and "liberated" the Baltic states. My interviewees tell me that before the arrival of the Germans, many Letts were forcibly evacuated into Russia, and many fearing the Germans fled voluntarily with the retreating Russians. A part of the remainder received the Germans as their liberators, took active part in rounding up of the communists, often cooperated in tracking down and exterminating the Jews, and adapted themselves to the Nazi order. Then again in 1944 the Russians started pressing at the borders, and now the Germans forcibly evacuated anybody fit for work. Those Letts who actively collaborated with the Germans fled voluntarily with the German Armies. They enjoyed reasonable freedom of movement and in general were not considered enemies.

They live now in displaced persons' camps. Their morale is that of voluntary exiles from their country, which they consider invaded by an enemy. Not having been submitted, at least in systematic fashion, to concentration camp regime they are in better health than the Jewish DP's. Convinced (or capitalizing on the assumption) that the war was fought for high ideals of liberty and the Atlantic Charter, many of them expect from day to day a clash between the western powers and Soviet Russia, for the primary purpose of restoring freedom to the smaller and now oppressed nations such as the Baltics and the Poles.

A camp of the Baltics, such as Lohengruen Camp, in Munich, impresses one by its organized self-government. There are schools from kindergarten to high school and junior college (equivalent to the Russian or German Gymnasium); there are a conservatory of music, a school of art, theaters, a library, and other cultural facilities. There are improvised churches of Greek Orthodox and Lutheran faiths. A number of their young people (summer 1946) attend the UNRRA university located in the remnants of the German Museum of Munich. As to their living conditions, there is no separation of the sexes, no separation by family units. Several families live in one room—often with one broad bed for a family. Where the bunks are double-leveled, there is often one couple, sometimes with a child, in the lower level, and another in the upper. Captain Bob Zeplack, for instance, who for sixteen years ran Standard Oil tankers along the American east coast and worked as a watchman in fashionable golf clubs in Pennsylvania, tells on the wire recorder: "In our rooms we are visually separated, but with our ears we all live together."

THE BALKAN DP'S

Like the Letts most of the Balkan DP's did not come to Germany voluntarily, at least not the civilians. They were conscripted by the Germans as laborers, or forcibly evacuated, or fled with the retreating Germans to avoid prosecution as alleged collaborationists. Part of the Balkan DP's are so called "white" Russians, former Tsarist officers who offered armed resistance to the advent of the Soviets in 1917 and 1918. When the forces of Baron Wrangel were beaten, part of the survivors escaped to Romania and Yugoslavia. They were "evacuated" by the retreating Germans.

THE POLES

Among the DP's are also the so called Anders Poles, variously estimated to exceed 50,000. These are

(Continued on Page 34)

Du Pont *Digest*

Items of Interest to Students of Science and Engineering

The Synthesis of Nylon

Chemists of original nylon research team honor memory of Dr. Carothers at the dedication. They are: J. W. Hill, Ph. D., M. I. T. '28; H. B. Dykstra, Ph. D. Ohio State '27; G. J. Berchet, Ph. D. Colorado '29; J. E, Kirby, Ph. D. Iowa State '29; E. W. Spanagel, Ph. D. McGill '33; D. D. Coffman, Ph. D. Illinois '30; and F. J. Van Natta, Ph. D. Michigan '28. Dr. Carothers received his Ph. D. from Illinois in 1924.

Dr. Wallace Hume Carothers

1896-1937, was the first organic chemist in industry to be elected to the National Academy of Sciences. During his short scientific career he made contributions that have greatly enriched American life.

Recently the Nylon Research Laboratory near Wilmington was dedicated as "The Carothers Research Laboratory," in honor of the late Wallace Hume Carothers and his classical researches on the structure of polymers, the mechanism of polymerization, and the invention of nylon.

In 1928, a group of chemists under Carothers began a study of polycondensation which led eventually to the discovery of nylon. The project was part of a program of fundamental research to discover scientific facts which might be of eventual value in laying a foundation for applied research.

As the first point of attack, they chose the condensation of dibasic acids with glycols and reaction materials which would preclude the formation of rings. They obtained linear polymers of molecular weights between 2300 and 5000.

Molecular Weights Increased

After two years, a significant advance in linear polymer preparation was achieved. Through the use of the molecular still, it was possible to obtain materials of molecular weights between 10,000 and 25,000, which, when molten, could be drawn into filaments.

More important, the cooled superpolyester filaments could be further drawn into fibers several times their original length and thereby acquired luster, tensile strength, elasticity, pliability, and toughness much greater than the initial polymer. In contrast with ordinary textile fibers, their tensile strength was unchanged by wetting.

The striking properties of the fibers aroused the hope of finding a commercial fiber from some type of linear superpolymer. Investigation showed, however, that fibers from the polyesters were too-low melting and too soluble for textile purposes. Mixed polyester-polyamides were also not of interest in this category.

Research on Fibers

The possibility of a commercial fiber development seemed remote, but the intuition that frequently accompanies research genius prevailed, and Carothers was encouraged to direct his research on superpolymers specifically toward spinnable fibers. A polyamide from 9-aminonanoic acid gave a fiber of 195°C. melting point, equal in strength to silk, and clearly indicated the possibility of obtaining a material for fibers of commercial utility.

In 1935, the superpolymer from hexamethylene diamine and adipic acid was first synthesized. It melted at 263°C., was insoluble in common solvents, tough, elastic and had the best balance of properties and manufacturing costs of any of the polyamides then known.

A third period of research covered commercial development. The task was enormous, and to reduce to a minimum the "time between the test tube and the counter" a large force of some of the most competent chemists, physicists, chemical and mechanical engineers available was assigned to the project. The story of the manufacture of nylon will be told next month.

(Continued from Page 32)

mostly members of Polish combat units who fought on the side of the Allies, and refuse to return to Poland while the present regime is in power.

THE MENNONITES

The Mennonites are a Protestant sect consisting of mild-mannered, soft-spoken people, who left Holland about two hundred years ago, ostensibly to avoid religious persecution and partly because of the shortage of farm land. On the invitation of the Russian Tsars they colonized some fertile tracts of southern Russia and were guaranteed freedom from compulsion to bear arms. In exchange for the latter privilege the Mennonite males had to serve in the forestry service of the Russian government.

Through all the years their language remained a kind of corrupted Dutch, while the church services still continue in German. The fifth column work of the Nazis caused the Russian security police to become suspicious of the Mennonites. The suspicions were nursed by the resentment of the Mennonites against the religious policies of the Soviets, and their opposition to the alleged efforts on the part of the Russians to force them into active military service. They admit that they saw in the advent of the Germans an opportunity for their liberation. They followed the retreating Germans into the present American zone. They were not interned by the Germans in concentration camps but were given work assignments and ration cards. And now they live in UNRRA barracks waiting for deliverance by their brothers in faith who reside at present in Canada, in the U. S. A., and in Latin America.

All together there are at present nearly a million people (not counting displaced Germans) who have been forcibly uprooted by the war and roam foreign lands in search of a place they can call their own. What they want most is a return to the simple requirements of cultured living. They crave some privacy. They want their own kitchens, their civilian types of clothes, they want little things which make life personal and which are the indispensable attributes of human life above the purely organic level. We must learn to understand that the DP's, in spite of their depredations, are not riff-raff, not the scum of humanity, not the poor devils who suffer because they don't know their rights, not idlers who think "that the world owes them a living," but people composed of all classes of society, comprising farmers, industrial workers, teachers, lawyers, artists, and the like, who have been dislocated by a world catastrophe.

If the atomic scientists have found themselves duty-bound to shout from the house tops about the social implications of atomic research, far more should the social scientist seize the opportunity to call for sympathetic understanding and dynamic assistance to a mass of humanity catastrophically submerged into a state of unprecedented suffering.

THE SCHOOLMASTER

Teachers. There is a temptation to try to estimate how many teachers the Schoolmaster has known, but probably no such estimate will be made. The number would be too obvious a reminder of the long time during which there has been opportunity to know teachers. Of course the urge to write a few paragraphs of reminiscence is a give-away about that long time.

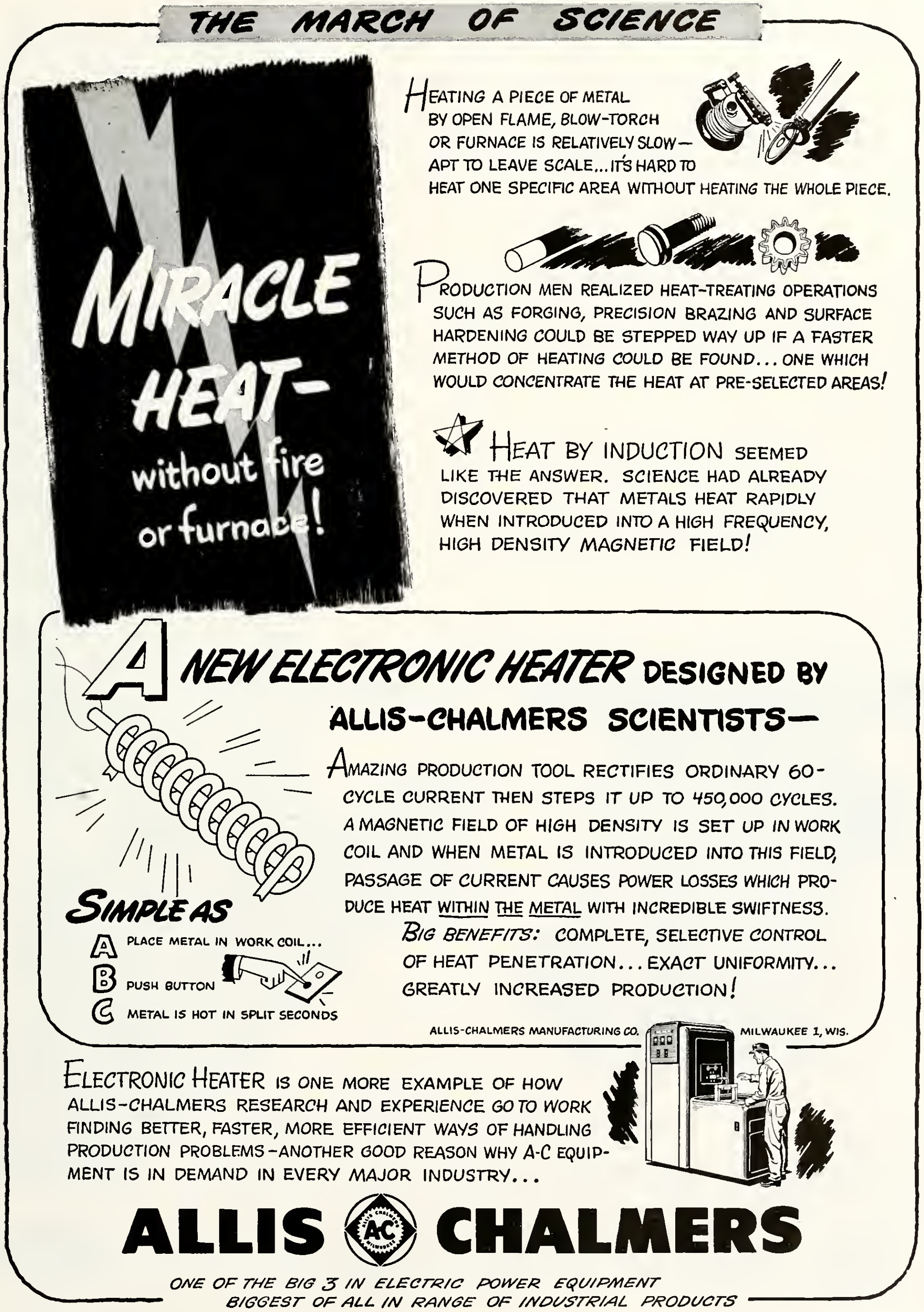
There comes to mind a comment by two young women, one a teacher of English in a college faculty, the other a physics teacher in a high school. They spoke of a man whose professional life had been spent mostly as a member of an engineering college faculty, and they said, "He has had no education." Of course what they meant was that he had never been taught how to teach, that he had never enrolled in a course called "education." They were stating a fact, not expressing an opinion of his effectiveness as a teacher.

A little lady used to teach the "first grammar" grade in a public school. Her pupils admired and respected her. They did not realize until later years how much affection there was in their feeling for her. Most of them, in their one year in her ninth-grade class, learned that it was a privilege to be associated with a lady and a scholar. She is now retired, welcomes letters from her boys and girls, and writes answers that indicate that her hand is still steady and her mind still young. Her address in a little seaside town is on South Pleasant Street, and this is fitting.

One of the first, perhaps the first, of the great leaders who organized research in pure and applied science for a giant industrial organization was one of the most successful and inspiring of teachers. Men who took his courses in physical chemistry will never forget Willis Whitney.

A teacher of a course in hydraulic measurements made the field trips to rivers and canals have the air of ex-

See SCHOOLMASTER on page 50


THE MARCH OF SCIENCE
MIRACLE HEAT- without fire or furnace!
HEATING A PIECE OF METAL BY OPEN FLAME, BLOW-TORCH OR FURNACE IS RELATIVELY SLOW—APT TO LEAVE SCALE... IT'S HARD TO HEAT ONE SPECIFIC AREA WITHOUT HEATING THE WHOLE PIECE.
PRODUCTION MEN REALIZED HEAT-TREATING OPERATIONS SUCH AS FORGING, PRECISION BRAZING AND SURFACE HARDENING COULD BE STEPPED WAY UP IF A FASTER METHOD OF HEATING COULD BE FOUND... ONE WHICH WOULD CONCENTRATE THE HEAT AT PRE-SELECTED AREAS!
HEAT BY INDUCTION SEEMED LIKE THE ANSWER. SCIENCE HAD ALREADY DISCOVERED THAT METALS HEAT RAPIDLY WHEN INTRODUCED INTO A HIGH FREQUENCY, HIGH DENSITY MAGNETIC FIELD!
A NEW ELECTRONIC HEATER DESIGNED BY ALLIS-CHALMERS SCIENTISTS—
AMAZING PRODUCTION TOOL RECTIFIES ORDINARY 60-CYCLE CURRENT THEN STEPS IT UP TO 450,000 CYCLES. A MAGNETIC FIELD OF HIGH DENSITY IS SET UP IN WORK COIL AND WHEN METAL IS INTRODUCED INTO THIS FIELD, PASSAGE OF CURRENT CAUSES POWER LOSSES WHICH PRODUCE HEAT WITHIN THE METAL WITH INCREDIBLE SWIFTNESS.
BIG BENEFITS: COMPLETE, SELECTIVE CONTROL OF HEAT PENETRATION... EXACT UNIFORMITY... GREATLY INCREASED PRODUCTION!
SIMPLE AS
A PLACE METAL IN WORK COIL...
B PUSH BUTTON
C METAL IS HOT IN SPLIT SECONDS
ALLIS-CHALMERS MANUFACTURING CO. MILWAUKEE 1, WIS.
ELECTRONIC HEATER IS ONE MORE EXAMPLE OF HOW ALLIS-CHALMERS RESEARCH AND EXPERIENCE GO TO WORK FINDING BETTER, FASTER, MORE EFFICIENT WAYS OF HANDLING PRODUCTION PROBLEMS—ANOTHER GOOD REASON WHY A-C EQUIPMENT IS IN DEMAND IN EVERY MAJOR INDUSTRY...
ALLIS AC CHALMERS
ONE OF THE BIG 3 IN ELECTRIC POWER EQUIPMENT
BIGGEST OF ALL IN RANGE OF INDUSTRIAL PRODUCTS

TEXTILES

(Continued from Page 12)

war 0.4 denier filaments were produced for parachute cloth. These fine fibers are now being employed in the making of fine fabrics for curtains and other sheer materials. It is also used for strong satin materials where its lack of elasticity is not a factor.

Rayon is made in both filament and staple lengths as well as in a variety of novel forms which have no counterpart in nature. This makes it very versatile in the construction of new, interesting, and novel materials.

Control of shrinkage, especially of the viscose type of rayon, since it has the greatest tendency to shrink, has been a subject for much research. From these investigations have come three methods which are being used on fabrics today. The first process employs synthetic resins of the thermosetting type. If the process is carefully carried out, a reasonably low residual shrinkage results; however on repeated severe launderings the resin or insoluble compound gradually leaches out and the fabric begins to shrink a little each time as laundering occurs. The second process, termed "definizing", treats the gray goods with caustic soda of high concentration, with immediate neutralization following. This process is being widely advertised and manufactured garments are coming on the market carrying a definized label. The third method, termed "BR-1 Rayon Stabilization Process", involves padding through a solution of glyoxal and an acid onto previously boiled off and dyed goods. The goods is then dried without curing. Curing follows, then washing out of any excess chemicals, neutralization of the acid in the fabric, and drying. This method when properly done shows exceedingly fine results even after repeated launderings.

Shrinkage control, which also stabilizes the fabric in most instances, is very important in rayons since laundering for many garments made of this fiber and some of the fabrics on the market today shrink as much as twenty per cent in a single washing.

Permanently crisp finishes are being applied to sheer rayons, especially to those employed for curtain materials. These are permanent and retard or prevent fading as well. The finish is a resin treatment.

Gas fading of acetate fabrics has been minimized or eliminated by the use of durable inhibitors during dyeing operations.

We find rayons used in blends or mixtures of practically every type of fabric. These play a real role in the textile picture, giving us new textures, materials, and a combination of properties. For example a rayon-wool blend may make it possible to eliminate the scratchiness of the wool and still produce a fabric of wool-like qualities. Cost is another important factor in the use of blended fabrics.

Flameproofing of fabrics, particularly the brushed rayon varieties, is becoming a reality. California passed a law and put it into effect January 1, 1947, prohibiting highly flammable materials for sale in their markets. The Federal government has also considered legislation of this type but no law has been passed. Methods and

(Continued on Page 42)

(Continued from Page 40)

equipment have been developed to test the flammability of fabrics. There are numerous finishes in use which fireproof or retard combustion in the material. Most of the treatments permit fusing or charring of the fabric, but no flame results. Many of these treatments wash or clean out, but can be renewed very easily. Other fabrics in addition to rayon are being flameproofed. Stain-repellent, water-repellent, and crease-resistant rayons are other improvements; a label on the article will state the finish and care required.

Silk is again making its appearance in greater quantities in our stores today; however so far it has been a luxury article. The price of raw silk is dropping on the market and we should see silks in the moderate price class before too long.

Linen was practically in the silk class, as far as availability was concerned, during these past few years. Now we are again able to secure fabries, yarns, and fiber from abroad and linens will come into our markets in greater quantities soon. Much experimentation has been carried on in the United States both in growing flax for fiber and in utilizing the fiber from flax straw, a by-product in the production of flax seed. We produce some fiber but it is not of the quality desired for fine household linens.

The production of nylon, which made its appearance shortly before the war, has been widely expanded. The fact that it can be thermoset to prevent stretching, shrinking, or sagging has developed a wide variety of uses for materials made of this fiber. Permanent creases or pleats can be set in fabrics made of nylon or nylon mixtures. Curtains, dresses, blouses, accessories, and a wide variety of other clothing items are being made. Nylon fabrics wash easily, dry quickly and retain their original shape; these factors in addition to sheerness with remarkable strength have made them desirable for many uses. Ninon and other sheer nylons are becoming available on the market in limited quantities.

Vinyon and vinyl resin with great elasticity is being found in surgical bandages today. Other potential uses are for shoe fabrics, bathing suits, curtain materials, upholstery fabrics, shower curtains, and awnings. Vinyon staple in combination with other fibers makes it possible to produce fabrics which will retain a pressed fold, shape, or crease.

Aralac, a fiber made from the casein of milk, is used chiefly as a blend with other fibers in clothing materials and hat felts. The proportion of aralac in any fabric usually does not exceed fifty per cent. Its wool-like qualities with good washability have made it desirable for many uses.

Fiberglass has been in use for some time; however due to the fact that any friction exerted on the fiber caused it to break or sliver limited its use to curtains, draperies and other like purposes. Now, a new finish is being ap-

(Continued on Page 44)

(Continued from Page 42)

plied to the fabric which controls abrasion and a wider variety of uses is visualized. This fiber is non-flammable, easy to wash and clean, and resistant to acids, alkalies and mildew; it is color-fast under all conditions.

Velon and saran are vinylidene chloride resin fibers made into single coarse mono-filament yarns. The color is added before extrudition. Velon was first used for shoe fabrics in combination with cotton yarn. Trimming materials, millinery and bag fabrics of unusual design, color, and weave have been developed. Saran was first used to make upholstery fabrics for seat covers in cars and public conveyances. The production of multifilament yarns of these two fibers is being developed with a wider variety of uses in view.

Plexon, a plastic-coated yarn utilizing cotton, rayon, or any other fiber as a core yarn is being made in a wide variety of colors and shapes. It is being used for hat braids and other novel yarn purposes. Plexon, like saran and velon, is easy to clean. Wiping with a damp cloth removes dirt, grease and other stains.

New coated fabrics, in which it is difficult to tell the uncoated from the coated, are being made. These are easy to clean, since wiping with a damp cloth cleans the fabric. Slip covers made of this type of fabric would be highly desirable. It is non-flammable, an important factor in plastic-coated materials.

New fabrics, new finishes and new uses are under way. To secure the best service from these new developments it is essential that the correct material for the purpose be selected and that the right care be given the fabric. Informative labelling has helped a great deal, when there is a label, and the purchaser reads it. Great strides were made before and during the early part of the war on informative labelling—then more pressing needs had to be cared for first. Now, with the war a thing of the past, we can hope for more progress in much needed service.

Developments in textiles have brought a need for more information on the part of the consumer, store merchandiser, buyer, and salesperson, as well as the sales representative for fabric houses and textile mills. This has been evidenced by the many inquiries received concerning textile courses offered in the Home Economics Department from those representing fabric manufacturers, buyers, and salespeople in ready-to-wear and yard-goods departments. Textiles are changing; if we are to be wise buyers and select the articles best suited to our purpose, as well as know how to care for them wisely, we need to know more about the materials which we buy today.

Served with Pride!

IN THE HOME or tavern where Pabst Blue Ribbon is served the good taste of the host is reflected in the good taste of this truly great beer... always full-flavor blended of never less than 33 fine brews . . . the one-and-only blended-splendid Pabst Blue Ribbon.

"It's Blended Pabst Blue Ribbon It's Splendid!"

BIARRITZ

(Continued from Page 7)

a plane would take them to America and return with the books. But these orders, like the others, were never filled.

A part of the difficulty was due to the egregious and arbitrary asses who thought themselves too large for their uniforms. The climax was reached when an instructor in philosophy, sent to Paris headquarters with a sheaf of book orders, spurred by curiosity opened the envelope and read the following:

"1. Attached requests by instructors at Biarritz American University for additional reference and text books are submitted for your amazement and for whatever action you deem necessary or appropriate.

"2. In view of the self-induced chaotic state of books for Biarritz, it is believed that the submission of these lists will add little to the present confusion."

Dr. Hendricks' class in Short Story Writing.

Needless to say, when the commanding officer was made acquainted with this missive, he acted with such force and speed that the officer who wrote it must have thought a tank corps had struck him.

Perhaps the instructor from the corn-belt of the mid-west characterized the situation best when he remarked, "If someone had tried to mess things up, he couldn't have done better."

Despite all this, the school moved steadily ahead, directed by a com-

(Continued on Page 48)

WHAT DO YOU SEE IN THE FUTURE?

SEVENTY-FIVE YEARS AGO half of the people of the United States were farmers. Life was simple in those days.

Every farmer knew just how much he had to raise on his land in order to support his family.

Every blacksmith knew how many horses he had to shoe in order to buy his wife a new dress.

Every farm-hand and blacksmith's helper knew how his wages depended upon his usefulness to the man who shared his income with him.

Life seems more complicated today.

Just about now the world appears to be in pretty much of a mess. Some of us are lost completely in the wilderness of theories and "isms" that surround us and have given up trying to find our own way. Many of us are following the leadership of guides who are taking us in many, widely opposite directions without our noticing this fact. We are behaving like lost hunters who refuse to trust their own compasses.

And yet, life is as simple as it always has been to those who follow the only guide that can take them to their desired goal—their own "horse-sense," their own conscience.

All the theories and isms cannot alter the fact that life depends upon our ability to earn a living. All the theories and isms cannot change the fact that our American way has produced the greatest nation on earth, enjoying the world's highest standards of living.

All the theorists and neoists cannot change these fundamentals:—

Business is the exchange of money for goods and services. Our earning power depends upon our ability to supply these goods or services.

But our earning power also depends upon our neighbors. We can prosper only as our community prospers—as our country prospers—and as the company prospers with which we are connected.

Learning these simple fundamentals is, in itself, a great achievement. It will solve most of our problems. Too many people go through life beating their heads out against them. Too many people fail to realize that these simple fundamentals are the basis of all sound business—that they are the key to every man's welfare.

Let those of us cling to these fundamentals who want our children to inherit a country that continues to offer freedom and equal opportunity for all.

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(Continued from Page 46)

manding general who performed his duties with devotion and distinction. Fortunate, too, he was in having as assistants, both civil and military, men who labored day in and day out to bring honor to the undertaking.

That the experience left its mark upon student and instructor alike, there can be no doubt. A chance remark of one student to another, both sitting on a cliff above the sea, represented a rather general impression. "You know," he said, "this is what I've always dreamed a college ought to be." And a paragraph from a letter sent back by one of the few hundred WAC's who had the opportunity of attending the University disclosed a similar attitude. "I cannot tell you how much—or what—Biarritz meant to me. Those two months, undoubtedly the happiest of my life, are like a marking point—pre and post. They clarified every thing for me, so far as my ambition and confidence to further it go. I went there confused, dependent on many people to prop my character and personality, unsure of any ambition or faith. I left — yes — still confused, though on a different scale, quite independent, but most important of all, ambitious again."

The attitude of the citizens of Biarritz was similar. When rumor spread, shortly before the end of the second term that the University would be closed, the people petitioned the mayor to appeal to the central government to intercede with the American ambassador to plead with the Army or the United States government to keep it open. More concretely, someone offered an estate or two, and many hoped that there could be found a way to continue this exchange of friendship.

Unfortunately, no way could be found. Moreover, the syndicates were itching to get back their casinos, the hotel-owner their inns, the wealthy their villas. But it was with sincere regret that the French and the Americans parted, and both were enriched spiritually and intellectually for having shared this experiment in education.

SCHOOLMASTER

(Continued from Page 36)

citing adventure, and organized the work on the drafting board so that each student felt that he was discovering for himself methods of graphic presentation and of analysis.

A professor of history, lecturing at a rate something like that of a radio version of one of the most tongue-tripping of the songs from south of the border, was completely intelligible, and an inspiring teacher. His brain was faster than his tongue, and the brains of his students were stimulated so that they kept up with him.

One engineering teacher, retaining the drawl of his southern home, thoroughly informed in his subject, treats his students like men and brethren, helps them on their way to a professional education, and finds himself continually called upon to give advice to his boys, young and old, although he has no formal responsibility for personnel and placement work.

Should a teacher have "education?" Of course there are techniques of teaching that can be learned. There are many brilliant men and women who have had no formal instruction in educational method. Possibly some of them might be less effective, less spontaneous, if they had taken courses in "education," but this seems improbable. Most of the teachers that we have mentioned were without special training in teaching methods. Our thesis is not that "education" is essential, nor that it is unnecessary. But two things are essential, knowledge of the subject matter, and desire to master the *art* of teaching. A man who does not love teaching will not teach well.

A young man, already well on the way to professional success in his own engineering field, asked the Schoolmaster for advice about the acceptance of a teaching position. He did not get advice, but he did get information. "Ten years from now, and for the rest of your active life, if you remain in your present work, your income will be more than a teacher's salary. But some of us prefer teaching to any other work in the world."

(Continued from Page 9)

trusion-detecting alarms. Thousands of vaults have sound or vibration detectors which sound an alarm in case of hammering on the vault wall. Burglar alarms with ears! In fact, an extensive research was conducted to learn exactly what kind and how much noise a burglar would make in penetrating various kinds of vaults so as to better define the safe limits of operation.

Other vault alarms utilize a pressure differential mechanism so sensitive that it can detect a hand-hole opening made anywhere through the wall of a vault.

Still another system used on safes utilizes magnetic wave principles; it literally feels the approach of the burglar to within a few inches of the protected object.

Many hundreds of installations in warehouses and factories are guarded by electric eyes. For this use, invisible rays rather than visible rays are projected through the area to be guarded. Interruption of a ray or failure of the photocell components instantly sends a silent alarm to a central station. Armed guards and police do the rest.

The trend in electrical protection is definitely along electronic lines. It would be very satisfying if, generally, the alarm protection could see or feel the burglar but he could not see it.

OUTWITTING THE BANDIT

Much that has been said about burglar alarm systems is true also of robbery-protective installations.

Take, for example, a bullet-resisting bank enclosure. A complete enclosure of laminated glass, steel, bronze and the like extends seven feet or more above the floor. Every device used in the barrier must be bullet-resisting and not be readily operable from the public side. Doors have automatic closers and locks. The materials used are tested at close range with high-powered small arms and proof-tested ammunition. Constructions which allow injurious fragmentation to the cashier's positions are rejected.

Tear gas for protection against robbery is another example. An investigation of tear gas involves almost every known branch of engineering. Fire and explosion hazard tests of discharge devices, chemical stability tests, electrical tests of controls and circuits, toxicity tests for safety of exposure to the gas, and finally, tests as to effectiveness of the gas. It's a sad day for the engineer, but he must know that the gas will repel a robber within three seconds—and there is no way of determining this except to try to "take it."

A cloud of tear gas issuing from a safe.

SAFES

Safes are a class of burglary-protective appliances which rely solely on mechanical resistance to entry. Obviously, protection of this character is relative, depending on the time, tools, and skill available to the criminal. A security chest may be classified as resistant to ordinary tools, to cutting torch, to high explosives, or to all three for a specified length of time. The development of these classifications and of testing techniques requires constant study of burglars' methods, tools used, and new tools or methods likely to be tried.

At an outdoor testing station high explosives are scientifically applied repeatedly to all vulnuerable parts of safes. Pressures of 200 tons and upward, applied suddenly, determine whether the burglar has much chance of succeeding. Users may be confident that a safe bearing the Explosive Resisting rating (Class X60 label) will withstand a lot of punishment. And, if the safe has a Torch and Explosive-Resisting rating (Class TX60 label) the burglar really has a tough assignment.

(Continued on Page 54)

What did you do today?

If you visited the waterfront[1]......or watched a plane[2]

...or turned on the radio[3].......or boarded a bus[4]....

...saw a freight car[5].......or went to the dentist[6]....

...lighted a candle[7].........or bought a necktie[8]......

K

KOPPERS

you saw a Koppers product in use[9]

1. Wood piling, pressure-treated by Koppers to protect it against marine borers. **2.** Koppers Aeromatic variable-pitch propellers. **3.** Koppers chemical ingredients for plastic radio cabinets. **4.** Koppers American Hammered Piston Rings. **5.** Wood for car construction, pressure-treated by Koppers for extra-long life. **6.** Koppers chemical ingredients for novocain. **7.** Koppers candles. **8.** Koppers chemicals for use in making dyes. All these are made by Koppers . . . as well as scores of other useful and familiar things. All bear the Koppers trade-mark of quality . . . the symbol of a many-sided service. Koppers Company, Inc., Pittsburgh 19. Pa.

(Continued from Page 52)

MORE PROTECTION NEEDED

Some may wonder why, with so many successful protective devices available, we still have crime. The reason is very simple. A large percentage of properties have inadequate protection for the exposure involved. Some have none at all. Where proper protection exists, experience shows that the immunity to attack is as much as thirty to one—that is, unprotected property is thirty times as likely to be attacked. Truly, the answer to crime is protection.

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CORROSION

(Continued from Page 17)

tact with a corrosive environment, even when the latter is no more than a damp atmosphere. An example of this nature is encountered in the case of sucker rods employed in pumping mechanisms.

Another example of failure, closely related to corrosion fatigue, may be illustrated as follows: If a ship's propellor is rotating at about the critical speed, a slight increase in speed will cause a vacuum to be established and a subsequent slight reduction in speed will cause the vacuum to collapse, the water entering the vacuous space with considerable momentum. Under such conditions the propellor is subjected to a series of shocks, which may eventully lead to failure.

A FEW USEFUL RECIPES FOR THE SHOP

Just to add a dash of practicality to this paper, a few simple recipes for use around the home and shop will now be given.

Garden tools, home implements, shop tools and various metal parts often require a more or less permanent corrosion preventive coating which can be readily removed when required, yet which is not rubbed off too easily. A non-drying compound suitable for this purpose may be made by melting lubricating grease in a can, placed in a pan of boiling water and adding, with thorough stirring, finely-powdered sodium chromate, in the ratio of 1/6 oz. of sodium chromate to one pound of grease. If thinning is desired, gasoline, kerosene, or petroleum naphtha may be added. Precautions must be taken to see that no open flames are present, as such mixtures are very inflammable. The thinner mixtures may be brushed on or sprayed, but the compound is better applied with a coarse rag. Articles having a polished steel surface may be cleaned with a hot soap solution and then dipped in the mixture.

The cooling system of the automobile is the part of the family car most susceptible to corrosion, as it consists of several kinds of metals and alloys, including brass, solder, iron, steel and zinc alloys all in contact with water solutions, which is an ideal set-up for electrolytic corrosion. For this reason, rock salt, calicum chloride or other salts should never be added to the cooling system to prevent freezing, as the increased concentration of dissolved matter in the solution accelerates corrosion. Alcohol, glycerine and ethylene glycol, on the other hand, actually help reduce corrosion from this source rather than accelerate it. One ounce of sodium chromate or sodium nitrite added to the change of water in an automobile radiator will reduce the corrosion effectively. If the water is acidic, enough sodium carbonate (washing soda) previously dissolved in a little water should be added to make the solution slightly basic as indicated by litmus paper. Greases should not be added to the cooling system as they

(Continued on Page 58)

(Continued from Page 56)

cause frothing, and deterioration of hose connections.

The chassis and springs of automobiles may be protected against corrosion by spraying or brushing with a preparation made by mixing lubricating grease, one lb., powdered sodium chromate 1/6 oz., S.A.E. 10 motor oil, 2 qts., and water, one ounce. The grease may be placed in a pail and heated by placing in a large pan of boiling water. When soft, the finely powdered sodium chromate and water are mixed in, and stirring is continued until a smooth consistency is obtained. The motor oil is then added and the mixture stirred until cool.

For removing rust spots from small steel implements such as carpenter's tools, a saturated water solution of stannous chloride is useful. The implements are immersed in the solution over night, when it will be found that the rust spots will disappear or diminish greatly through reduction. Upon withdrawal from the solution, the instruments should be rinsed with water, placed in a hot laundry soap solution and dried. Cleaning with a little alcohol and polishing with wax may follow.

Sometimes a permanent rust preventive finish is desired for small steel objects or art ware. It may be obtained by suspending the well-cleaned iron parts for a few minutes in a solution of copper sulfate, which causes a thin skin of copper to form on the surface. If the pieces are now rinsed off with water and then moved about for a few minutes in a solution of sodium thiosulfate acidified slightly with hydrochloric acid, they assume a blue-black coating of copper sulfide which is quite permanent in both air and water. The black surface may be immediately rinsed with water, dried with a rag or blotting paper and polished. It possesses a steel-blue luster, adheres well to iron, and protects against corrosion in a very satisfactory manner.

CONCLUDING REMARKS

With the costs of equipment, installation and labor ever increasing, management of industry, in an attempt to maintain a workable profit margin, has finally become aware of the great loss due to corrosion. This awareness, that if even a very small percent of the annual loss were used to support fundamental research in corrosion a substantial saving might be made, is responsible for the increased flow of funds to support such work. The government is also involved in the problem because of thousands of tons of intricately-built equipment, now stored in military warehouses, which must be ready for action on notice ranging all the way from thirty days to perhaps twenty years. The corrosion protection measures involved are on an unprecedented scale.

It is realized that metal protection cannot be acquired without cost and that it should be considered as an investment or insurance, rather than a speculation. An investment in corrosion protection, upon which the success of the large investment in metals, fabrication and installation may depend, is now deemed worthy of close scrutiny. There is a re-awakened interest in the fundamental aspects of the corrosion problem in the universities and other laboratories devoted to more fundamental research as is evidenced by the rapid acceleration in the publication of technical papers dealing with corrosion. During the year 1945 alone, approximately 1200 articles on the subject were published.[7] It can therefore be said, at long last, that the empirical art of metal protection is gradually giving way to the science and engineering of corrosion control.

[7] R. D. Misch, J. T. Waber and H. J. McDonald; *Bibliography of Corrosion Literature for 1945*; Book Dept., National Association of Corrosion Engineers, Houston, Texas (in press).

CONTRIBUTORS

(Continued from Page 4)

activities pertaining to the production of oxygen for the armed forces. Dr. Rushton is a member of the American Chemical Society, American Institute of Chemical Engineers, American Society of Mechanical Engineers, Society of Chemical Industry, American Society of Engineering Education, and the Chemists Club of New York. He has been chairman of several committees in these groups and is at present a member of the Chemical Engineering Education Accrediting Committee of the American Institute of Chemical Engineers.

The cover picture shows a small portion of a model of the new campus, designed by Ludwig Mies van der Rohe. Several new buildings are finished, and others are in course of construction.

"*Without laboratories men of science are soldiers without arms*"—LOUIS PASTEUR

Why some things get better all the time

The span of life is increasing. Within the last half century the average length of life of a new born infant has increased over 30%. And many more people over 40 can now expect to live well into their seventies.

Among the reasons for this progress, along with notable advancements made by the medical profession, are the improvements in medicinals and medical equipment that help guard life.

Synthetic organic chemicals now are used in the production of a host of pharmaceuticals, including penicillin and the sulfa drugs, which have accomplished wonders in the fight against germs. They also are used in repellents to defeat disease-carrying insects. Out of research with gases has come oxygen therapy, an aid to recovery in numerous illnesses. Research with metals and alloys has produced the gleaming, easy-to-clean stainless steel used in modern hospital and medical equipment.

In safeguarding life—just as in transportation and communications—much of man's progress is traceable to *better materials.*

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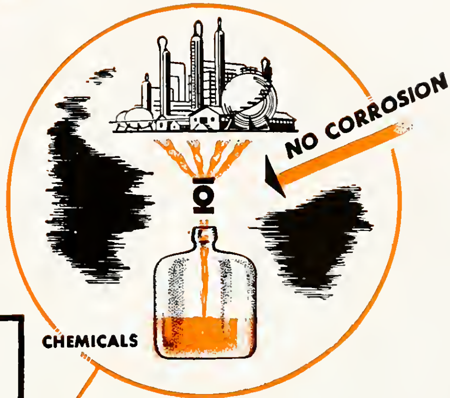
OXYGEN

(Continued from Page 26)

would require substantial alterations and improvements in furnace design to withstand the increased temperatures.

Table 3 shows that about one-half (126) of the blast furnaces are in the classes of 600 to 900 net tons/day. Without changing the volume of the blast but enriching it to 26 per cent by means of 95 per cent oxygen the amount of the latter required would be, in round numbers, from 7 to 10 tons/hr. with an average of 8.5 tons for each blast furnace or about 200 tons/day. These are small units compared with oxygen plants for Synthine installations which will be four or more times as large. Oxygen plants in multiples or in larger sizes may be indicated to supply 95 per cent oxygen for several furnaces simultaneously in one steel works.

Plants for the production of oxygen for use in steel operations are being built in the United States. Should the promised advantages in this field alone prove to be justified, as is confidently expected, the production of "tonnage oxygen" will constitute an industry of considerable magnitude.



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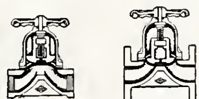
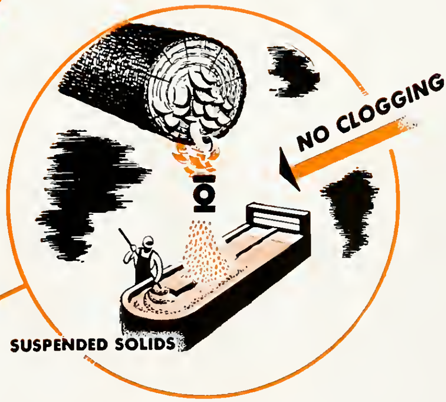


Open   Closed



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ILLINOIS TECH ENGINEER

MAY, 1947

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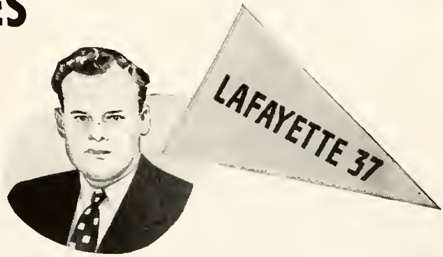
Campus to GENERAL ELECTRIC

TOMORROW'S APPLIANCES

The Story of

JIM YOUNG



THE General Electric refrigerators, ranges, washers and other appliances that homemakers will be buyng in 1950 are already under development. James F. Young, ten years out of Lafayette College's mechanical engineering school, supervises the engineering of these appliances-to-come.

Jim, graduating magna cum laude, chose General Electric's job offer over others because, as he says, "G.E. offered more different fields of engineering, had a better program than any other company, and could provide better experience."

The varied experience that Jim sought came to him fast. While on "Test" with G.E., he worked in four different plants and at six different assignments, ranging from supercharger tests to studies in unbalance of hydraulic systems. Following "Test" he enrolled in the G-E Creative Engineering Program and drew five assignments in laboratories and design departments.

When he had completed the course he was appointed supervisor of it. While organizing this course and lecturing to the class, he studied another—the C course in mechanical engineering. He also wrote and edited "Materials and Processes," published in 1944.

His first "real work," he says, was in helping to develop large-size rocket launchers, both airborne and land types. The creative engineering ability he showed on this assignment, and on later problems, insured his steady progress to the top of the Advance Engineering Section of his company's Appliance and Merchandise Dept.

Next to schools and the U.S. Government, General Electric employs more college engineering graduates than any other organization.

Jim became interested in mechanical problems early. In his teens he found a hobby in rebuilding old autos.

As an early job with G.E. he organized and taught engineering courses, became supervisor of all mechanical engineering training.

During the war he helped develop the airborne rocket launcher, important factor in smashing Nazi armor. A second war job: development of gyroscopes for torpedoes.

Today Jim supervises the engineering of G-E household appliances to be marketed two to five years from now. He still directs the training of many new engineers.

GENERAL ELECTRIC

CONTRIBUTORS

James I. Banash is one of the country's foremost authorities in the field of safety and fire and accident prevention. A graduate in electro-chemistry of the Massachusetts Institute of Technology, Mr. Banash has specialized in fire and accident prevention in their relation to the physical and chemical sciences. Several years ago he achieved prominence for his work with artificial atmospheres high in oxygen, in relation to therapeutic application. He was with Underwriters' Laboratories in Chicago for twelve years and became head of the Casualty Department. During recent years he has been in consulting practice in Chicago. He is consulting engineer for the International Acetylene Association, and is an active member of many other engineering and research societies. In 1932 he was elected president of the National Safety Council. Prior to this he had served the Council as chairman of the American Society of Safety Engineers Section, as treasurer, and vice president for finance. He has been a member of the Council's Executive Committee since 1928. Since 1931 he has served as the National Safety Council's representative on the National Fire Waste Council.

Marvin Camras was born in Chicago in 1916. He received the B.S. degree in electrical engineering from Armour Institute of Technology in 1940, and the M.S. in 1942. Since 1940 he has been on the staff of Armour Research Foundation, where he has done much work in the field of magnetic recording. Papers on this subject have been presented by Mr. Camras before the Society of Motion Picture Engineers, the Chicago Acoustical Society of America, and the New York Electrical Society. Mr. Camras has also worked on a variety of other projects in the electronics department: remote control, high-speed photography, magnetostriction oscillators, and static electricity. He is a member of the Acoustical Society of America, the American Institute of Electrical Engineers, Tau Beta Pi, and Eta Kappa Nu.

William H. Hyde is librarian and associate professor of library science at Illinois Institute of Technology. He received his B.A. degree from Oberlin College; his B.S. and M.S. degrees in library science from Columbia University; and has studied at the University of Chicago. He has worked in the New York Public,

*See **CONTRIBUTORS** on page 4*

The Cover Picture shows a bridge of the Chicago, Rock Island and Pacific Railway over the Cimarron River at Kismet, Kansas. Five 250-foot single-span trusses, E 72 railroad loading.

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CONTRIBUTORS

(Continued from page 3)

and the Columbia and Cornell university libraries. He is chairman of the Engineering School Libraries section of the American Library Association, on the executive committee of a similar section of the American Society for Engineering Education and is also a member of the Chicago Metropolitan Library Council, Special Libraries Association, and the Chicago Literary Club.

Earl C. Kubicek is Executive Secretary of The Illinois Tech Alumni Association. Further information is contained in the Contributors' Column of the December, 1946, issue.

William A. Lewis, Dean of the Graduate School had his engineering experience in the Los Angeles shops of the Westinghouse Electric Corporation. Winning a Westinghouse War Memorial Scholarship, he attended California Institute of Technology and obtained the degree of B.S. in 1926, M.S. in 1927, and Ph.D. (summa cum laude) in 1929. He returned to Westinghouse in the Central Station Engineering Department at East Pittsburgh where he was concerned with problems of power-system stability and relaying, carrier current, railway electrifiication, and many individual system problems. He was also active in teaching in the Pitt-Westinghouse graduate training program. In 1939 he was appointed Director of the School of Electrical Engineering at Cornell University. He joined Illinois Tech in 1944 as Consultant in Electrical Engineering at the Armour Research Foundation and as Research Professor of Electrical Engineering. In September, 1946 he was appointed to his present post.

Henry Penn was born in the Netherlands, and came to Chicago as a small child in 1890. His boyhood and his professional life therefore span the period of rapid growth of steel construction in this city. He graduated in the department of civil engineering at the University of Illinois, and most of his thirty-six years of experience has been in structural design and in construction. For five years he was on the faculty of Armour Institute of Technology (now I I T), and for one year he was coach of the baseball team. He still enjoys speaking of both of these assignments. Since 1928 Mr. Penn has been District Engineer for the American Institute of Steel Construction. He is a member of the Triangle, Tau Beta Pi, and Chi Epsilon fraternities, and a registered structural engineer and professional engineer under Illinois laws.

See CONTRIBUTORS on page 56

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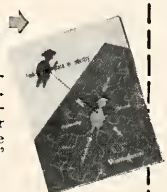

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Some Modern Uses For Packaged Gases

By J. J. Banash

Many new uses of compressed gases, as well as variations of old uses, should be well worth consideration by graduate and undergraduate engineers. In a short article it is possible to discuss only a few more recently developed uses of compressed industrial gases and perhaps some of the common industrial practices which may not be covered in all engineering classes. This article will deal with the gases making up the air and a few others that are used in combination with oxygen.

An indication of the importance of the compressed gas industry in the country is that it is about the ninth largest industry in the United States from the point of view of investment. This gas business delivers for the most part a relatively cheap product in an expensive package. For example, about two dollars' worth of oxygen is delivered in a thirty-dollar package. This means that quick use of the contents and prompt return of the cylinders are necessary if the compressed gas industry is to remain economically sound and prices of gases are to be kept low.

Gases under very high pressure are being shipped in cylinders. These cylinders are made of special high-strength steels under careful controls. Pressures of the gases range from a few pounds up to 2,200 pounds per square inch. All cylinders moving in interstate commerce are made in accordance with Interstate Commerce Commission specifications and are so marked for easy identification. Many states now require that cylinders for intrastate shipment also comply with I.C.C. specifications, which have proved quite satisfactory over the years. One reason for the success of I.C.C. cylinders is doubtless the required periodical inspection and retesting. Many high-pressure cylinders are tested by the magnetic particle method, and often they are rejected for flaws which to the average person would seem quite minor.

We live surrounded by air which is a mixture of gases, at what we call atmospheric pressure. This varies with the altitude and at sea level it is 14.7 pounds per square inch absolute. The relative proportions of this mixture consist of 78.03 per cent nitrogen, 20.99 per cent oxygen, 0.93 per cent argon, one part in sixty-five thousand of neon, one part in two hundred thousand of helium, one part in one million of krypton, and one part in ten million of xenon. Minute amounts of other gases are present, such as hydrogen, carbon dioxide, water vapor, ammonia, and the oxides of nitrogen. In this discussion, however, these gases are considered as negligible impurities.

OXYGEN

Obviously the most important of all gases to man is oxygen, whose continuous supply is absolutely necessary for life. We could go a month without food, nearly a week without water, but not over five to eight minutes without oxygen. The supply of oxygen is taken for granted and is practically unlimited, for about half the earth's crust is oxygen in one form or another. The proportion in the atmosphere, about twenty-one per cent, does not vary and is generally sufficient for maintenance of life. Of course when disease interferes with ordinary respiration, sufficient oxygen may not reach the tissues of the lungs. Supplementary oxygen has to be supplied in treatments called inhalational or oxygen therapy. Such oxygen-want (anoxia) was known medically 150 years ago, but the treatment was not a success at that time because of the inadequate apparatus for administration of oxygen and the absence of manufacture and distribution of oxygen in suitable quantities. Today, oxygen therapy is a generally recognized treatment, and most of the oxygen manufactured in this country is suitable for administration to human beings. The United States Pharmacopeia requires a purity of ninety-nine per cent oxygen. Most industrial oxygen exceeds this specification. Today, oxygen is used so freely that some hospitals have oxygen piping systems which carry the gas from the manifolded cylinders to hundreds of bedside outlets. Ambulances, emergency police squads, mine-rescue teams, and many other similar life-saving groups are equipped with small cylinders of highly compressed oxygen and the necessary administering apparatus.

During the war oxygen was tremendously important. The lessons we learned in the high-altitude flights of bombers and fighter planes are now being used in industrial aviation to meet the problem of inadequate partial pressure of oxygen in the atmosphere above 10,000 feet. Oxygen for aviation must be free of moisture to avoid freezing the controls of a mask or other device. Peacetime industry has been greatly helped by results of research made during the war by our Air Forces and by manufacturers working closely with the military establishment on oxygen supply sys-

In the foreground are oxygen cylinders and acetylene generators to supply the gases used in pressure-welding 24-inch overland pipe line by means of the apparatus hanging over the pipe.

tems, regulators, special types of equipment, and cylinders. For example, low-pressure chambers built during the war for the study of altitude conditions at ground level are now available for further research.

The use of oxygen with acetylene for welding and cutting is familiar to many people. Acetylene, an extremely important industrial gas, may be used from a cylinder into which it is compressed or it may be used directly as generated from calcium carbide and water. The compression of acetylene into a cylinder is unusual because free acetylene should not be stored at a pressure above 15 lb. per sq. inch. Acetylene cylinders are packed with a porous material. The fine pores are filled with acetone, a liquid that has the property of dissolving or absorbing many times its own volume of acetylene. Acetylene may be stored in a compressed gas cylinder of this type with perfect safety, and such cylinders are charged to a pressure of about 250 lb. per sq. in. at 70 deg. F.

Our ships, tanks, armaments, and defense plants of various kinds could not have been produced without the flexibility and utility of the oxy-acetylene process, which has become a universal tool of industry. New techniques of steel-conditioning facilitated the tremendous output of the steel mills. Fairly recent is the spectacular development of a machine that de-surfaces hot steel billets right in the roll line. This machine literally skins off the outside surface to prevent defects which would later develop in the rolled product. The de-surfacing operation actually increases the temperature of the billet instead of allowing it to cool. The de-surfacing operation can also be done by hand on cold billets. An outgrowth of this is the oxy-acetylene gouging process for removing excess metal and for cleaning out defects in heavy welds.

Hundreds of miles of over-land pipe lines and many thousands of rails have been welded by the oxy-acetylene pressure-welding process, a fairly recent development. In pressure-welding, the parts to be welded are forced together by great pressure. At the same

time they are heated by oxy-acetylene flames to a temperature at which the metal becomes plastic but not fluid. The pressure forces the abutting surfaces together to form a weld that has the unusual characteristic of having no metal added from a rod or other source. In other words, the parent metal makes the weld. This type of welding makes possible the joining of considerably dissimilar steels. Special pressure-welding machines for performing many different types of operations are being constructed for industry. Although these machines involve some expense, the result is a lower unit cost for a particularly sound weld.

The largest proportion of oxygen used in industry at present is for severing steel. This depends on the fact that iron burns in pure oxygen at a temperature below its melting point. The cutting torch heats the metal with a number of oxy-acetylene flames surrounding the central orifice, through which a stream of oxygen is released. When the metal is heated to a visible red, the cutting oxygen stream is turned on. The oxygen stream striking the heated iron makes a continuing cut as the blowpipe is moved along. The development of oxy-acetylene cutting has so advanced that today steel up to sixty inches thick can be cut with oxygen pressure on the cutting jet of less than eight pounds per square inch.

Engineers generally may not be aware of the wide scope of methods for welding or cutting metals. Most of them may have noted the extreme portability of the outfits for repairs, but one must actually enter our large factories to see the most recent development of automatic operations where intricate shapes are automatically cut by machines guided by templets. Several blowpipes may be cutting simultaneously, all guided by one templet, or one moving blowpipe may be cutting many plates stacked one on the other.

The volume of oxygen and acetylene used in such processes is so great that the gases are brought to the point of use through piping systems from large banks of manifolded cylinders. Where the volume of oxygen used is extremely large, liquid oxygen is delivered to a plant, placed in a special container, and then expanded into gaseous oxygen before it enters the pipe lines. In some industrial plants where requirements are moderately large, storage units are installed outside of the buildings; they consist of banks of long high-pressure tubes or portable cylinders manifolded together. These units are charged from a truck that carries liquid oxygen and equipment which converts the liquid to gas. The oxygen is discharged at 2200 lb. per square inch.

Recent developments in oxygen uses border on the dramatic. For instance, the iron-mining industry is now considering the use of lower grade ores. Some of these cannot be mined economically because the ores are not only low grade but are so very hard that the costs of drilling are out of proportion to the value of the ore. Recent experiments with a new process called fusion-piercing have been announced in the *Engineering and Mining Journal* (October and November, 1946). They indicate how this can be accomplished with a rotating blowpipe on a long shaft which directs against the rock surface a flame using oxygen and a special flux. The intense heat melts the rock, and the velocity of the flame and gases blows the material past a rotating water spray above the burner tip and carries all this exhaust material out of the hole. It is interesting to note that a 6-in. diameter hole, 30 feet long, has been drilled at as high a rate as 17 feet per hour, whereas ordinary methods yield about one foot per hour.

After the hole is drilled, the blasting can be done without dynamite or powder. A carbonaceous material in a suitable bag is impregnated with liquid oxygen. The bags are loaded into the drilled holes, and any number of blasts may be set off at once by a detonating fuse. No dangers arise from misfires by the use of liquid oxygen explosives, because bags that fail to explode soon lose the oxygen by evaporation and thus are non-explosive.

Another interesting use of oxygen is in a rather novel chemical procedure for "sweetening" gasoline. Oxygen is used in combination with copper chloride to convert mercaptans to disulphides. This removes the source of odors in the end product.

Ones imagination is almost staggered by the possibilities now being worked on for the use of oxygen in tremendous quantities, not necessarily of the highest purity, for speeding up operations in open hearth furnaces, blast furnaces, and in chemical transition processes such as the Fischer-Tropsch method of producing gasoline. If these later developments are successful, the volumes of oxygen involved may be so spectacular as to make our current use of oxygen seem small in comparison.

Before leaving the subject of oxygen, attention may be directed to its use in producing synthetic sapphires. The war brought on the necessity for providing an American source of synthetic sapphires for instrument jewel bearings. Cut off from European supplies, intensive research was instituted, and, as a result, quality synthetic sapphire was successfully produced in large amount.

Synthetic sapphire, also known as corundum, is produced by feeding finely divided particles of alumina into an oxy-hydrogen furnace. This alumina is fused in the flame and built up on a clay pedestal in a carrot-shaped form known as a boule. The process has also been developed to produce long, slim rods of corundum which facilitate bearing production. At first, only white sapphire was made, but now practically any desired color is produced. In addition to bearings, the material is widely used for semi-precious jewelry. Because of its optical properties, it is going into use where a high percentage of transmission of certain wave lengths of light is necessary, such as ultra violet, for special irradiation purposes. The material also is used for the working ends of gauges, outlasting the best steel gauges many times.

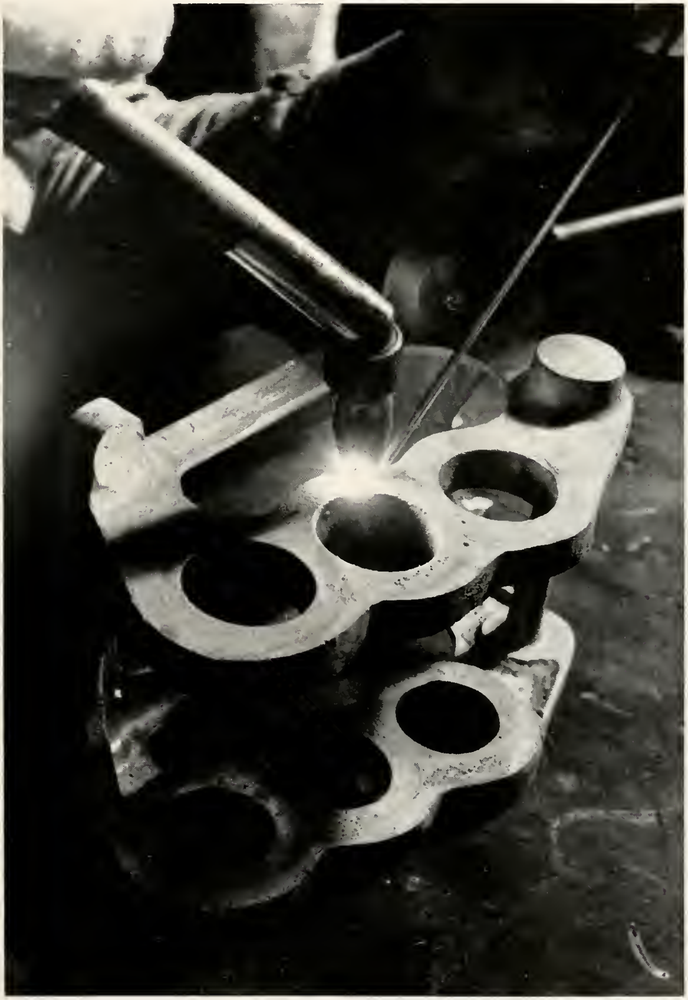
Synthetic sapphire can be given an exceptionally smooth surface and is next in hardness to the diamond on Mohs' scale, with an index of 9 as compared to 10 for the diamond. This combination of smoothness, hardness, and homogeneity makes it suitable for applications such as jewel bearings, injector nozzles, and wherever such

highly polished surfaces are necessary to prevent abrasion and wear.

NITROGEN

Nitrogen is the largest constituent of the air. It is separated by the air-liquefaction process. Until recently high-purity nitrogen in industry has been used less than oxygen. In general industry, nitrogen has been used for its relative chemical inertness at ordinary temperatures. During the war a greatly increased demand for nitrogen for special purposes resulted in much greater production.

In the food industry, a stream of nitrogen flows through cylinders in the processing of animal and vegetable oils and fats. Such materials are particularly susceptible to oxidation, resulting in very undesirable changes in taste and flavor. Therefore processors are greatly interested in excluding oxygen as completely as possible throughout the entire process of manufacture and packing. If solid oils are treated in a vacuum, pure nitrogen is now used instead of air to break the vacuum. It has been customary to whip five to ten per cent of air into a finished product to improve the physical characteristics. Now manufacturers are substituting nitrogen to avoid incorporating oxygen into the product. Also producers are removing the air from the head space in containers and filling it with nitrogen. This practice allows a long period of shelf-life under quite adverse conditions without deterioration in flavor. The wider use of dehydrated foods has shown that bacteria will ultimately cause them to deteriorate. The substitution of nitrogen for oxygen in the container allows an extended time interval without deterioration in shipping and storage before use, even in very hot climates. The process helps maintain flavor, prevents loss of certain vitamins, and inhibits growth of mold. The Army used tremendous quantities of dry whole milk, dry ice-cream mix, dry egg powder, nuts, and citrus products. Nitrogen packing was of great importance in reducing the residual oxygen to the smallest possible amount. Investigation is now under way to apply similar procedures to a number of other food products. For example, continuous churns make it possible to whip nitrogen into butter. Air with its oxygen content is eliminated, and the inert nitrogen helps keep the natural flavor. In the pharmaceutical field, nitrogen is used in packing numerous dietetic products and in the processing of vitamins. The paint and varnish industry likewise uses increasing amounts of nitrogen to protect products which deteriorate from the effects of oxygen and moisture.



In this repair of a magnesium casting the heated zone is surrounded by the inert gas argon which flows out of the torch around the tungsten electrode.

For centuries the metal-working industry has used heat in the close fitting of one metal part around another. In modern industry the reverse of this procedure is frequently preferable, that is, cooling the metal so that one part will fit inside another. When working with close tolerances and where very tight fits are necessary, it has become more and more general to cool the inner piece with liquid

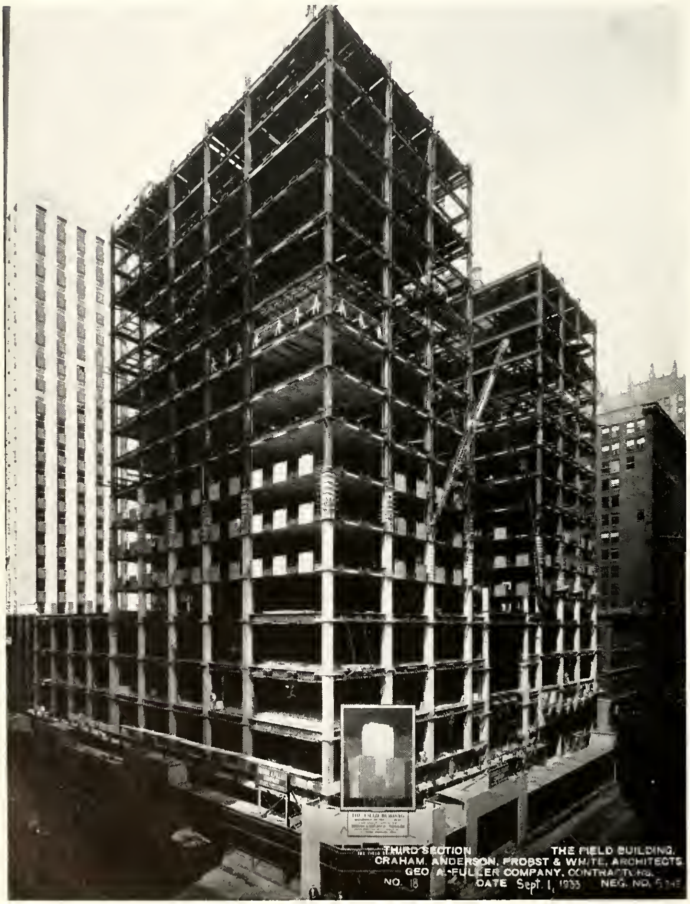
See GASES on page 58

ROMANCE IN STEEL

By Henry Penn

Whenever the steel industry is mentioned in the public press, it is said to be "big business". Just how big is it? In 1929, the ingots, or poured blocks of steel, produced in the United States amounted to approximately three and one-half pounds per day for each person of our entire population. During the war years it reached a figure of almost four pounds per capita per day, in spite of our increase in population. These quantities are so enormous that no other metal is really comparable.

We cannot well consume steel literally, but try to think of something in your daily life in which steel does not play a part. For every metal or material, steel supplies the tools for development for man's use. Now the figures given before extended into annual production are enormous, but no one has an idea of the total number of tons of steel that are in constant use to which we add our annual production and from which we subtract that which goes back to the steel mill as scrap. The tremendous production and use of steel plays an important part in the industrial development of our country as compared with other nations.



Historical information on steel is interesting. We commonly hear of three ages of man—Stone, Bronze and Iron. These ages are not separated by exact dates. In fact, the ages lap over one another; in the same way any new article does not now immediately displace those previously on the market, but must gradually develop its usefulness. Since the various metals and other elements are not equally abundant in all parts of the world, the ages do not start everywhere at the same approximate time.

In Egypt, Chaldea, Assyria and China, the Iron Age reaches back to about 4000 B. C. In Africa, the use of iron succeeds the Stone Age direct. In Europe, iron was used before Julius Caesar's time. As the story goes, in Tyre, steel swords were tempered by plunging them thrice through a slave's body after heating to a sun red and cooling to a royal blue. When finished, the sword had to stand the test of cutting off a slave's head in one blow, and bending into a circle with the ends touching without breaking. Later, village blacksmiths used similar tempering methods with water as a cooling medium, thus making a tremendous saving in manpower. These early steels and irons were made in crude forges by processes not adapted to produc-

tion in large quantities. The ancients could not easily produce the temperatures that are necessary for modern steel making.

In 1450 A. D., cast iron was produced by the blast process in Middle Europe. Cast iron contains iron and carbon with carbon content of more than one per cent. The difference between steel and cast iron that affects their relative usefulness lies principally in the physical properties of the two metals. While cast iron can only be formed while changing from a hot liquid to a solid, steel can be cast in a liquid state and formed in either hot or cold form by a number of processes. Physically, cast iron is a hard, brittle material, with a relatively low tensile strength. Steel is a tough, ductile material with practically equal compressive and tensile strength. Steel can be made to have a variety of characteristics by controlling the chemistry of its manufacture.

In 1854, just a few years before our Civil War, the Bessemer process was invented. It was developed in France and America at the same time. The process consists in blowing air or oxygen through molten cast iron. The oxygen unites with the carbon of the cast iron. The resulting combustion burns out a portion of the carbon and raises the temperature of the residual molten mass so that it can be cast into steel ingots. Thus, at one stroke, the problem of the ancients was solved, and cast iron was converted into steel in large quantities.

In 1864, the open hearth process was invented. This method uses fuel for heating and reduces the carbon by the introduction of iron oxides. This process made better steel, since it permitted control of undesirable impurities. Cheaper ores can be used.

In 1880, we have the beginning of the Steel Age. A hot ingot was converted into rolled shapes and a great upheaval in civilization was on its way. The statement has been made that in the last sixty years, ninety per cent of all human knowledge has come into existence. Regardless of the accuracy of these figures, or the surmise that this is a coincidence, we do know that in that short period of time, we have learned to make steel so cheaply that the new use of steel annually is three and one-half pounds per person per day.

Highway Bridge Over the Chicago, Burlington and Quincy Railroad at Albia, Iowa.

To tell the entire story of the use of steel does not come within the scope of this article. Books could be written on the subject. A brief survey of the use of steel in the construction field will illustrate the possibilities in this material. The construction industry annually uses between ten and fifteen per cent of the steel produced in the United States or, say, one-half pound per person per day[1]. The material is used in the buildings and structures of commercial, industrial and governmental enterprises as well as the bridges of our transportation systems.

The steel construction industry draws its basic material from the rolling mills. It consists of plates and members of various shaped cross sections, such as angles, channels, I-beams, and others. The size of the pieces varies according to the use to which they are to be put. A plate may be a fraction or several inches in thickness and up to 144 inches in width. An I-beam might be up to 36 inches in depth, or might weigh 426 pounds per foot of length. In the book *Steel Construction*[2] complete detailed characteristics and information in regard to design use may be found.

In making these shapes, the mills refine the steel in the open hearth furnace, pour it into ingots, and then roll it at the proper temperature into the desired section. Steel is worked and reworked, rolled and rolled again, until the metal has a uniform, fine grained, tough texture. The chemical properties of steel are more accurately fixed than are the properties of a medical prescription compounded by an expert pharmacist. By controlling the chemical components in thousandths of a per cent, as is done, steels of any desired characteristics may be obtained. All the physical properties are tested and known before the material is used. Metallurgists and chemists control the manufacture to the end that architects and engineers, who work with structural steel, have the assurance of recognized and tested strength—uniform, consistent in every fiber.

The architects and engineers who make the designs of buildings have the task of delineating on blue prints the dreams of an owner, whether for a commercial, industrial, or other type of building. The over-all plan must, of course, house the functions which the owner has planned. In detail, however, each column, girder, beam, truss, or brace, must be carefully considered as to the desirability of its location, and its size, to meet the load which will probably be put upon it when the structure is occupied. In making his plans, the designer soon learns of the value of the high strength that steel possesses, for it permits columns and beams to be relatively small in area; steel weighs less per strength unit than

[1] See *Steelways*, Jan. 1947, published by Amer. Iron and Steel Institutes.
[2] Published by the American Institute of Steel Const., Inc.

any other structural material. Thus the planner makes a paper picture of all the parts that make up the structural frame of the building.

Many types of building are necessary to the complex existence of the people of our country. Apartments, schools, university buildings, hospitals, office buildings, hotels, and warehouses are usually of a type known as multi-story or tier buildings. Industrial buildings are, generally speaking, one-story or roof buildings because the plant operations are carried on the main floor at ground level. Churches, power houses, and similar structures are specially designed to fit individual cases. In most of the types indicated, no general rules can be laid down as to how to achieve the lowest cost. In many cases it is necessary to carry out studies with various layouts in order to determine which would make the most desirable arrangement.

The history and development of some of the types of building is very interesting. Styles of architecture usually are the highest development of the structural frame available in that type. The column and beam, arch and buttress, mark the limits of certain forms. It was a long while before modern architecture stood out and was recognized in the multi-storied building. In it are expressed the horizontal and vertical lines of the structural steel frame. The skyscraper is thus America's principal contribution to architecture, but it is a large one.

Early tall buildings were constructed with heavy load-bearing masonry exterior walls. The interior framing was usually column and girder, but lateral stability came from the heavy walls. The exterior walls were decorated in Georgian, Classic or other styles of architecture.

In 1884, William LeBaron Jenny designed and began the construction of the Home Insurance Building on the northeast corner of LaSalle and Adams Streets in Chicago. In the desire to obtain adequate daylight in the rooms of this office building, the windows became so large that the remaining masonry wall was insufficient to carry the loads of the floors adjacent. The designer overcame this problem by carrying the walls on structural framing and columns and thus was born "skeleton" type of framing. The owners and the designers were thoroughly aware that they were using a new type of building construction. The available materials for the frame were cast iron columns, cast iron lintel beams, and, in general, wrought iron I-beams. By permission of the designer, the Carnegie-Phipps Co. supplied one shipment of the new rolled steel beams for use in the frame. Thus, in the first skyscraper (seven stories high) there was also early use of steel beams.

The skyscraper has developed by leaps and bounds because of the tremendous possibilities of riveting together structural steel members of almost unlimited size. So today we have buildings like the Empire State in New York, over 1250 feet high, and others similar to the Field Building in Chicago (illustrated here), which stands on the site of the Home Insurance Building.

Industrial buildings have increased in dimensions horizontally rather than vertically. In earlier days, it was thought that an economical construction for a manufacturing plant could be a multi-story building in which the raw materials were lifted to the top floor and traveled down through the building and out of the main floor as package goods ready for delivery. It has long since been proven that the processes can be laid out in plan, with horizontal transportation, and the whole economically housed with spans adjusted to by-pass the production machinery.

The variety of such structures is unlimited. Chain-store warehouses of the one-story roof variety have been built with 550,000 square feet of floor area. The columns are spaced 24 feet on centers in both directions, and the total amount of structural steel involved has been not more than 4 pounds per square foot of the area. In steel mills, cranes having 150-ton capacities roll on rails 100 feet apart and 30 feet above the ground or working area. Buildings for the manufacture of airplanes have been 320 feet wide by 4000 feet long, and the row of columns near the center of the width were 200 feet apart. Sports buildings have been built having 250 feet clear spans.

From the foregoing, it should be quite evident that the structural steel frame of every building is more or less special. There are practically no two buildings for which the same design drawings could be used. In a multi-story building, there may be a series of beams that are duplicated. In an industrial building, there may be a number of trusses that are alike. No "stock" pieces of building frames can be found. Even with the duplication indicated, it should be considered that this very superior building material is custom built for each individual structure.

In a similar manner, bridges are designed for each situation on the highway or railroad system. The spans, heights required, lanes of travel, number of tracks, and many other items, enter into the selection of the type of bridge to be used. They may be simple spans, or continuous spans of girders or trusses. Trusses may be deck or through. Arches, suspension bridges, movable spans, and countless other forms, are possible. The largest could be considered as the Golden Gate Bridge of 4200 feet clear span, and the lowliest may be a simple beam span over a creek. Into this maze of types, the engineer tries hard to weave some consideration of beauty of structure by careful study of form and line; perhaps of the handrail, alone, in the case of the simple beam bridge.

Who makes the "pieces" that must fit together into the whole building frame, or bridge? The steel construction industry, consisting of about 250 shops, large and small, competes for the opportunity to perform the work shown on the drawings by the engineers or architects. These shops have the responsibility of seeing that the correct material is ordered from the mill and fabricated to dimensions such that it can be assembled into the completed structure according to the designer's conception. Again, one of the fine characteristics of the steel frame becomes apparent in that it can be checked for size and shape of material, even after it has been erected on the site.

The business of fabrication is also concerned with three kinds of fastening. The parts of a structure, building,

or bridge are attached to one another by riveting, bolting, or welding, or by a combination of these methods. Following the designer's blue prints, the engineer of the fabricator has the problem of designing the connections and making up the complete details or dimension drawings for each piece in a structural frame. From these detail or shop drawings the order for the steel from the mill is compiled. To properly make these drawings, it is necessary to understand shop practice, shop standards, tolerance permitted in steel fabrication, and the specifications under which the material is to be made, as well as necessary steps in erection that are to be followed. Most of the designers have found themselves greatly aided by the fact that as young engineers they had the opportunity to learn how to detail fabricated structural steel in connection with shop practice.

Riveting can be done with either hot or cold-driven rivets. The holes are punched or drilled or are reamed to a given size from a punched hole. Punched holes are not perfectly cylindrical and may show the sides of the holes as torn metal. On more important work this damaged metal is reamed out. Prior to driving the rivets in the holes, the work is partly clamped by means of bolts so that good alignments will result. Common sizes of rivets are three-fourths and seven-eighths inch. Rivets have one made head and are entered into the holes and upset so that a head results on the other end and the shank fills the hole. Heating the rivet to a temperature of 1600° to 1900° F. before driving simply makes it easier to upset the metal during driving. Rivets have been used for many years and the engineer knows how they will act. They inspire confidence in that they lend themselves to visual inspection.

Bolts in structural steel are growing in popularity because only two men are required in a gang compared with four men in riveting. It is also easier to teach proper methods of bolting than riveting. In bolted work, the shear and bearing values have been assumed the same as rivets if the hole has been carefully made to be not more than 1/50 in. larger than the bolt. Where ordinary unfinished bolts are used, without close tolerance as to size of hole, a reduced value is permitted. The Metropolitan Insurance developments in Greater New York, approximating 100,000 tons, are so bolted. The more modern method may prove to be the use of the bolt as a clamp with a known tension, thus creating a friction load in the transfer of loads.

Arc welding finds almost general use in the fabricating shop. It does many odd jobs. In addition, for a modern design where much duplication can be achieved, there may be considerable economy. Its principal disadvantage lies in the fact that something, such as a jig, must be used to hold the piece to the proper physical dimensions. Spot welding for structural thicknesses is being developed for use similar to arc welding. The fabricating industry is progressive and will find the best uses for all of these types of fastening.

No story of a material is complete without a recitation of its work in the recent war. The greatest need developed in the last half of 1940 was for industrial buildings, and more industrial buildings, in which the production of war goods could be carried out. Structural steel was the natural answer because of the fact that it could be speedily and economically built and could be erected anywhere and in any weather. After two strenuous years of this class of work, it became apparent that here was sufficient production area in buildings, and the industry, with its normal market practically cut off, turned to other fields. After much pressure on the ship yards and the Navy, it began to build landing craft, sections of corvettes, and 4000-ton coastwise freight ships. Large segments of ships were made miles away from the water in the Central West. Shipped by freight, they were erected into full hulls in the ship yards on the Great Lakes and the rivers, from which they moved down the Mississippi to do their part in the great war. The precision with which parts of ships could be built by this steel fabricating industry contributed in a large measure to the speed with which assembly and fitting yards could place the boats in service.

In structures it is often necessary to protect structural steel against certain destructive agencies by coating or surrounding it with other materials. Where corrosive conditions arise, it is usually protected by paints, asphalts, coal tar products, and similar coatings according to the nature of the corrosive agents. Where a fire resistive building is required, the structural steel frame can be clothed in various masonry units, or coatings of plaster. Engineering laboratory tests definitely establish requirements parallel to the hazards involved. These protective problems for structural steel should be looked on as a part of engineering design as much as the selection of the size of member to be used.

Buildings are not always satisfactory to new occupants. Steel frames lend themselves to easy alteration. Modern stores are kept modern by installing new escalators which require large floor alterations. On walking through the First National Bank in Chicago on the main floor, the casual observer will think from the column lines that it is a single building, but inquiry would disclose that the altered steel frames of at least five buildings occur between the bank floor and roof.

Structural steel will last indefinitely. The Eads Bridge over the Mississippi River at St. Louis, completed in 1874, after seventy-two years of service, is still a modern bridge. When its floor system and sidewalks have been altered, it will again be ready for modern traffic for an indefinite time. The material is ageless.

Steel is a versatile material. You are living in a steel age. Everywhere are tons and tons of steel serving man's needs in production, and in housing his endeavors industrially, commercially, religiously, and in every way. Even the lowly one-story house can be better for the use of structural steel. A great contribution to architectural style is the skyscraper which gets its line from the horizontal and vertical members of the steel frame.

When a piece of steel has outlived its usefulness in one form, it goes back to the mill as scrap, to come forth again in some new form ready to serve.

THE GRADUATE SCHOOL

By W. A. LEWIS

The year 1947 marks the tenth anniversary of the formal organization of the Graduate School of Illinois Institute of Technology under the administration of a dean. Although some graduate work was offered earlier, it was limited in extent, and complete programs leading to advanced degrees were first organized and offered in 1937. This article describes the present development of the Graduate School and reviews briefly its history.

Graduate study at Illinois Tech has a two-fold purpose: first, the advanced training of scientists and engineers for industry; and second, the development of the teaching and research staff of the institution. Under present competitive conditions the usual four-year technical course of study does not provide a sufficient training for solving the complex technical problems of industry, especially those involved in research and development. Although experience in industry itself, as always, is one of the best teachers, industry more and more is recognizing the advantages of further formal training as a means of utilizing recent developments and of improving the methods of attack on complex problems. The classroom is generally recognized as the best place for acquiring mastery of analytic tools based upon mathematical reasoning, and the laboratory for developing experimental techniques. Many of the larger industries are themselves developing training programs for their younger employees which include intensive classroom instruction. In order that the staff shall become and remain competent to conduct graduate courses and advanced undergraduate courses it is essential that at least some of its members conduct research of high quality and maintain active contact with industry through part-time consulting, summer employment, and participation in the technical activities of the scientific and engineering societies. The Graduate School serves as the means of promoting, sponsoring, and coordinating these activities.

Graduate courses in 1947 will be offered in the following fields: Architecture and City Planning, Biology, Business and Economics, Chemical Engineering, Chemistry, Civil Engineering, Electrical Engineering, Fire Protection and Safety Engineering, Industrial Engineering, Mathematics, Mechanical Engineering, Mechanics, Metallurgical Engineering, Physics, Political and Social Science, and Psychology and Education. However, the degree of Master of Science is available only in the fields of: Architecture, Biology, Chemical Engineering, Chemistry, City Planning, Civil Engineering, Electrical Engineering, Mathematics, Mechanical Engineering, Mechanics, Metallurgical Engineering, and Physics. The degree of Master of Science without designation may be conferred when the program meets the general requirements, but not the specific requirements of one of the designated degrees. The degree of Doctor of Philosophy is offered in the same fields as the master's degree when the research equipment and the interests and qualifications of the staff are well fitted to give the specialized work desired. Many of the graduate courses are offered in the evening so that they may be available not only to graduate students on the campus but also to other graduate scientists and engineers who are employed during the day. To provide maximum opportunities, graduate students who have adequate previous records may pursue their studies on a full-time or part-time basis, day, evening, or both.

The degree of Master of Science requires in general one full year of academic work beyond the bachelor's degree in the corresponding undergraduate field. Students whose undergraduate work has been pursued in another field must take additional undergraduate work to remedy these deficiencies. If the deficiency in undergraduate preparation is substantially less than two semesters of advanced undergraduate work, the student who possesses a bachelor's degree in a related field may be permitted to register as a graduate student and pursue the required undergraduate courses simultaneously with appropriate parts of the graduate program. Of course, the total time required to obtain the advanced degree is extended. If the undergraduate work required amounts to a year or more of academic work, the student must register as an undergraduate until his deficiencies are removed.

For the degree of Doctor of Philosophy a total of three years of work beyond the bachelor's degree is required. The master's degree is a desirable, but not necessarily a required, step in the process of obtaining the doctor's degree. Study for the doctor's degree must be concentrated in a major field and in two minor fields of interest not too closely related to the major field.

For both the master's and doctor's degrees a research project is required, which is selected by the student, and is pursued under the guidance of an adviser or advisory committee. For the master's degree the research project represents about one-fourth of the year's work and for the doctor's degree approximately one of the three academic years involved. The report on the research is submitted in the form of a thesis which must be ac-

cepted before the degree may be awarded. It is expected that the thesis will contain material which is readily publishable and for the doctor's degree a deposit is required which is not refunded unless the material of the thesis is published in satisfactory form within eighteen months after the degree is conferred. Usually the research work is performed on the campus, but in special cases it may be conducted elsewhere, particularly in those cases where industry or some special laboratory offers facilities of particular value which are not available on the campus. However, unless the work is under the full direction of a faculty member, the credit allowed will normally be reduced, so that additional course work will be required to meet the degree requirements.

The detailed rules regarding these requirements as well as the transfer of credits from other institutions, the inclusion of advanced undergraduate work as part of the graduate program, requirements for admission, and similar questions are all given in the Bulletin of the Graduate School, available to anyone interested upon request.

Although comprehensive programs leading to advanced degrees as the certificate of successful completion are generally desirable in technical work, it is well recognized that many able students do not have the need for or interests in a complete program, or do not have the resources to permit spending all or a major portion of their time in college for one or more additional years. At the same time advanced training in particular subjects is of direct value in their work. Evening graduate courses frequently provide the desired advanced work for this group, and the planning of the evening graduate program is done with this end in view, as a service to the surrounding community. Scholastic requirements for admission to particular evening courses of such technological value may be somewhat lower than for admission to a program for a graduate degree, so that in general all those able to profit adequately from the advanced training may be admitted. Eligibility is determined from the scholastic average of previous work on the basis that an A grade is counted as 3, B as 2, C as 1, D or E as 0. The minimum weighted average, as computed by multiplying the semester hours of credit in each course by the number for the grade received and dividing by the total semester hours, must be at least 1.5. Some deviations are of course permitted to allow for differences in grading systems at various colleges and universities, based upon the experience with graduates of those institutions. On the same basis formal admission to the graduate school, to pursue a program leading to an advanced degree, requires a minimum scholastic average of 2.0, or in general a B average.

Students who are able to take additional scholastic work only in the evening may arrange a graduate program so that a master's degree may be obtained based entirely on evening (or in some cases Saturday) classes. This requires a minimum time of three years but the usual time for such a program is four or five years. In the same way part of the work for a doctor's degree may be completed, but at least part of the program must be taken in a more concentrated schedule in a day program.

The location of the Institute within easy travel distance of the center of Chicago makes the facilities of the Graduate School available, either day or evening, to a majority of the possible graduate students. However, there are many who because of the travel distance, irregular hours of work, or other causes find it impossible to attend. To help in the advanced training of such students, the Institute undertakes to provide extension courses in remote centers when suitable arrangements can be completed. Usually these courses are conducted in the plant of an individual company, and the subjects offered are selected to meet the needs of the particular student group. In the Graduate Training Program of the Allis-Chalmers Manufacturing Company in West Allis, Wisconsin, the Graduate School offers a program of studies which leads to a master's degree in either electrical or mechanical engineering, based upon evening study and a thesis, usually developed from work conducted in the plant or laboratories of the company but representing a special concentration of effort on the part of the student. The courses offered are essentially the same as the corresponding courses given on the campus, and so far as possible the same instructors are used, the instructors traveling weekly from Chicago to West Allis. A series of courses in applied mathematics is being conducted in Peoria for the research engineers of the Caterpillar Tractor Company and a course in mathematics and in radio is being conducted at the plant of the Belmont Radio Company. Cooperation in graduate instruction with the Carnegie-Illinois Steel Corporation results in the granting of limited graduate credit for approved special graduate courses in metallurgical engineering given in the South Works of the company. A similar arrangement is in operation with the Commonwealth Edison Company for certain electrical courses, and other extension programs are being developed. Although the students in these programs do not have direct access to the laboratories and library of the Institute, the facilities provided by the companies have been found adequate, and the opportunity to apply the advanced training immediately and directly to industrial problems often results in an educational experience which is superior to that possible in full-time college attendance.

Developing and maintaining a staff capable of providing adequate instruction in graduate courses requires the encouragement of research and investigation by staff members. The spirit of inquiry and the desire for new knowledge are best inculcated in students by the example of their teachers and the inspiration of leaders in the field. Scientific research may take many forms and the equipment required may vary from an elaborate laboratory costing millions of dollars to the pencil and paper of the mathematician or analyst. In every case, however, motivation is provided by a desire to find answers to unanswered questions, be they large or small. The most elaborate and expensive laboratory is useless if not manned by people capable of using it wisely, and many of the greatest discoveries have come from meagre

See GRADUATE SCHOOL on page 40

Lightning Protection In Review

Research Method Yields Dividends in Power System Reliability

By E. R. WHITEHEAD

To operating and maintenance engineers of electric power systems, April showers bring more than the promise of May flowers, for they also mark the beginning of the so-called "lightning season". It is noteworthy, however, that in most states there is no month entirely free from thunderstorms.

The general problem of protecting electric power systems from equipment damage and service interruptions caused by lightning has many interesting aspects. It is the purpose of this article to present a brief review of the work leading to the establishment of basic principles pertaining to this problem, to indicate how these may be applied to certain illustrative situations, and to point out some of the phases in which there appear to be opportunities for effective work on the part of graduate students interested in this field.

LIGHTNING AN EARLY PROBLEM

About 1880, small isolated power plants marked the beginning of the great industry which can be justly proud of its record of "enough and on time" during the late war. In those days, operators were plagued with insulation breakdown resulting from "static" during thunderstorms, and it was not uncommon for them to shut down the generators and connect the overhead lines to earth for the duration of a thunderstorm. Today we know that the transient voltages appearing on power lines as a result of lightning discharges are far from "static"; indeed, the major problems requiring solution are the result of the heavy transient currents which accompany such disturbances. Looking backward, one can almost draw the conclusion that success in lightning protection has been achieved in virtually direct ratio to our knowledge of the lightning current which may appear in various parts of the system.

Broadly speaking, lightning has been defined by the A.I.E.E. as an electric discharge in the atmosphere, one terminal of which is a cloud. Such a discharge may give rise to transient voltages on electric power lines in two principal ways. When a lightning stroke occurs between oppositely charged regions of a thundercloud or between cloud and earth without coming in contact with any portion of the power system, the rapid changes in the electric field can result in impulse voltages which are commonly known as "induced surges". The stroke may, however, strike some point of an electrical circuit directly, so that all the current involved must find its way to earth through one or more elements of the electrical system. Such cases are known as "direct strokes".

Prior to about 1928, it was generally thought that the lightning stroke current was of the order of several hundred thousand amperes and that the time of discharge was of the order of five to twenty microseconds. If directly intercepted by a conductor of the system, such currents could not be passed to earth without damage somewhere. On the other hand, experience had shown that early lightning protective methods did reduce equipment failures and service interruptions, and the conviction naturally grew that "induced surges" were responsible for the greater proportion of system flashovers and equipment failures, and that effective protective methods could be devised for such surges.

RESEARCH PROGRAMS

Between 1918 and 1930, the continued growth of power systems resulted in the need for higher transmission voltages together with more system inter-connections, and the large blocks of power involved justified reasonable efforts to provide the utmost in service reliability. Accordingly, the problem of lightning protection in all its phases took on new importance, and both field and laboratory research received increasing attention. Impulse generators were devised to produce "artificial lightning", and the cathode

ray or electronic oscillograph was developed to record such transients accurately.

In 1927 "artificial lightning" was impressed on a 22,000-volt subtransmission line of the Duquesne Light Company in Pittsburgh, Pennsylvania. These tests were limited in scope and in voltage, but they served to verify certain theoretical relationships and showed the need for the greatly enlarged field test programs which followed from 1928 to 1932. Field research in this period was pointed toward the dual objective of determining the properties of traveling waves on transmission systems using "artificial lightning" produced by portable surge generators, and of measuring the actual voltages produced on such lines by natural lightning. Laboratories were set up in Michigan, New Jersey, Tennessee, Illinois, Pennsylvania and Arkansas.

DIRECT STROKES MOST IMPORTANT ON HIGH VOLTAGE LINES

Because of their economic importance, most of the work outlined above was done on high voltage lines; that is, 66 kv to 220 kv, and one of the important points in question was whether "induced surges" or "direct strokes" were responsible for tripouts on such lines. Research engineers soon reported seeing many strokes to earth near the lines to which their oscillographs were connected without the initiation of voltages of sufficient magnitude to result in line flashover, and in many cases these induced surges were only a small fraction of the flashover levels.

"Near miss" by a lightning stroke causes no tripout on 132 kv and 220 kv transmission lines.
(Photo by courtesy of Westinghouse Electric Corporation)

Figure 1 shows a photograph obtained by the author during one such investigation in which the stroke to earth was located approximately 250 feet from the transmission line without resulting in sufficient induced voltage to initiate the operation of the electronic oscillograph. Consideration of these and related data led to the conclusion that "direct strokes" were largely responsible for lightning tripouts on high voltage lines. By the time this conclusion had gained general acceptance and the emphasis shifted to the new problem of securing data on the nature of lightning current, the full force of the depression was felt. Nevertheless, the indispensable work of Lewis and Foust, Waldorf, McEachron and McCann was carried out, and today we know much about lightning current. Taken together with the work of B. F. J. Schonland in South Africa, one can obtain a good picture of the mechanism of the lightning stroke itself from these researches.

This brief historical outline is intended merely to point out the background with which protection engineers are familiar and which the power transmission student will do well to assimilate.

FUNDAMENTAL PRINCIPLES

Volumes have been written on the results of field and laboratory studies of lightning phenomena and space does not permit an attempt at a summary. We may, however, state certain general principles which have emerged. In the course of the field studies, it became evident at an early date that practical and reasonable designs of electric power equipment and

circuits could not be made to withstand the unrestricted transient voltages which might be imposed upon a transmission system by lightning. Thus the basic problem may be separated into two equally important components, the first having to do with the determination of the impulse breakdown voltages of all classes of electric power insulation, and the second the investigation of means by which lightning voltages could be limited. Actually, each of these components has many special problems, and in the case of transformers and rotating machines, studies of voltage distribution and propagation within windings are especially important. Finally, we add the important requirement that the means of limiting the abnormal voltage should not of itself introduce an additional hazard to service continuity. Under certain conditions it may be permissible to waive this last requirement. Our basic principles then are:

1. It is impractical to provide sufficient insulation to withstand unrestricted abnormal voltages which may be impressed on transmission systems by lightning.

2. Means must be devised to limit the abnormal transient voltage without introducing additional hazards to service continuity.

3. Impulse breakdown voltage values must be established for all insulation elements employed in the construction of electric power equipment.

4. All parts of the system must be designed so that the levels obtainable from (3) are substantially greater than those of (2).

The extent of the margins called for in (4) is largely a matter of economics and the desired degree of freedom from residual lightning failures or service interruptions, and much effort has been expended to standardize these matters with respect to apparatus design.

PROTECTION METHODS

It is not possible to discuss here the many improvements in lightning protection which have resulted from the application of these principles, but some illustrative examples may be of interest.

As we have seen, lightning usually causes abnormal transient voltages and currents either by induction or by direct contact with overhead wires. In either case these abnormal voltages and currents may be greatly reduced or virtually eliminated by the proper use of additional multi-grounded wires so disposed as to intercept direct strokes and to possess maximum electromagnetic coupling with them. With present knowledge of the proper physical arrangement of such wires, they may be carried over important generating and substations so that the probability of lightning damage is reduced to a very low value. Even under these conditions, however, it is still possible for expensive and important station equipment to fail, and frequently excellent overhead ground wire protection is supplemented by lightning arresters located adjacent to or perhaps mounted directly upon major station apparatus.

Often there is room for ingenuity and economy even where the utmost in reliability is desired. To illustrate the application of the general method given above, an actual design will be cited. A steel company load of approximately 30,000 kw was supplied from a nine-mile radial line at 66 kv. The line was designed to average about one tripout every 2.5 years, using good ground wire protection carried over the terminal stations. As the probability of a stroke reaching the power conductor was extremely small, only light-duty lightning arresters were mounted on the transformers at a considerable saving in material and structure cost. Finally, in order to prevent transformer or arrester failure even if a stroke should manage to reach a power conductor of the line, inexpensive "back-up" gaps were so located that the sum of the lightning arrester and inductive potential drops would result in gap flashover. In six years of operation, there have been no interruptions of service caused by lightning although the line is exposed throughout its length and as many as thirty lightning arrester operations in one year have resulted from the reflection of small induced surges at the terminal station. In this example, the primary means of voltage limitation consists in the properly located and well-earthed shielding or ground wire. The coordinated use of lightning arresters and a back-up protective gap of special design contributes the necessary elements to provide an extraordinary degree of freedom from interruption of service and damage to equipment resulting from lightning.

Subtransmission systems utilizing wood pole overhead lines have been extensively built without overhead ground wires for reasons of economy. Frequently, however, their high insulation levels make it possible for severe surges to be transmitted into substations. On one such system, early designs of lightning arresters had been widely applied, but station equipment failures were still numerous. Power company research engineers set to work to determine the insulating characteristics of station equipment and the voltage-limiting abilities of both old and new types of lightning arrester through exhaustive laboratory tests lasting many months. It was found that it was not only essential to raise insulation levels in many cases, but also that it was imperative to discard the old arresters and install hundreds of modern units which could hold the lighting voltages to safe values while passing several times the lightning current permitted by the obsolete arresters. Insulation levels were pushed up, voltages allowed were pushed down. Results—an eighty-five per cent reduction in substation equipment failures from this cause.

Frequently power system engineers are confronted with the problem of deciding whether new transmission lines must be added to accommodate increased generating capacity or whether existing lines can be reinforced for this purpose. In one such case, a double circuit 66 kv steel tower line was found adequate with respect to current carrying capacity, but a limitation was placed on system output because of interruptions caused by lightning. Since the cost of a duplicate line and terminal equipment exceeded one million dollars, it was decided to investigate how the line might be improved to provide a high degree of

See LIGHTNING on page 30

The Engineering Library—Storehouse Or Laboratory?

By WILLIAM H. HYDE

Engineering libraries may be of various types but all are primarily departmental in that they serve a highly specialized field of interest. There are independent technological institutions supported by private, state, or federal funds, separate colleges attached to large universities, departments of public libraries and also private corporations and businesses all of which maintain libraries of this specialized character. These libraries offer a tremendous range in size and purpose, from such as John Crerar in Chicago, Massachusetts Institute of Technology in Cambridge and the Engineering Societies' Library in New York whose collections contain hundreds of thousand of volumes and are administered by large, well-trained professional staffs, to collections of a few handbooks, texts and current issues of professional publications for quick reference use in the office of a practicing engineer or professor and cared for by a secretary. The library of the Illinois Institute of Technology contains about 110,000 volumes of books and periodicals, covering the fields of study offered by the Institute but strongest in engineering and science.

Engineering differs in no way from other professions in depending upon the printed word for most of its learning, and engineers, like scholars generally, turn to libraries in order to extend their knowledge beyond their immediate experience. This is true in all the functions of engineering as well as in the branches and it is the purpose of the library to provide immediate access to published material with little delay and at a moderate cost.

The salient role of the engineering library is not only to prevent duplication of effort and to avoid waste of time, money and energy on the part of those engaged in original investigations in technology but also to furnish the material needed by those practicing the functions of any of the branches of engineering. This information includes not only the background literature and the basic underlying principles but, fully as important, the latest developments as well. Adequate use of library facilities would do much to overcome two serious errors frequently made by scientists and technologists—duplication of work already described completely and the failure to appreciate investigations decribed almost verbatim in the literature. Too often there has been failure to uncover many investigations published in rather obscure form because of incomplete or inadequate searching of the literature. The library also furnishes the means of locating the information if it is to be found in print elsewhere than in the immediate collection being used.

Little attention has been given to the library needs of the engineer in the past, and provision for engineers in even the largest universities and public libraries has been below the level maintained for other departments. In fact, the development of engineering libraries as such has been a phenomenon almost entirely of the twentieth century. However, as engineering has become more of a science and less of an art, its literature has also become more important. Indeed scientific literature today has atttained tremendous proportions and its volume increases at a much faster rate than that at which it can be readily digested and efficiently utilized. This has resulted in a recognition of the fact that only through libraries can the adequate record of engineering progress be kept and engineers keep in complete touch with professional developments. Since the proper use of a technical library presupposes a knowledge of its facilities, familiarity with library research procedures, and an appreciation of the scope and character of the literature of each subject field, it is unfortunate that the average users of library facilities has little conception of how to use the library aids which are at his disposal when left to his own resources.

The teaching function of the library, which is now becoming more generally recognized, has on the whole been badly neglected in the past. Few engineering libraries offer more than a general lecture on the use of the library to the entering freshmen and still fewer librarians have been able to gain the support of their administrators to conduct even one course in teaching the use of the library and its resources, although the difficulty in using the highly specialized material may be acknowledged. It would be more effective if engineering school libraries were administered for active co-operation in the educational program they serve and had a definite place in the engineering curriculum, integrated with previous library instruction. Pressure from business concerns, aware of the graduates' inability to collect and locate wanted information for reports and investigations, is

See LIBRARY on page 34

ARMOUR RESEARCH FOUNDATION

Recent Developments in Magnetic Recording for Motion Picture Film

By MARVIN CAMRAS

There are three fundamentally different sound recording methods that can be used with motion pictures. A mechanically cut or embossed recording was originally the most highly developed method. The "first" talkies used a phonograph disc which was synchronized with the picture. Many of us can probably still remember the synchronization trouble that sometimes occured.

Because of such faults, and for other reasons, the optical sound track method was developed and adopted. In this method the optical track is an integral part of the film. In the projector the track runs between a light source and photo-electric cell, and thus it modulates the light passing through the photograph in accordance with recorded waves. The optical sound track is so satisfactory for most sound-on-film work, and particularly for commercial motion pictures, that it is now used almost exclusively. However, in addition to requiring separate processing and printing, it is complicated, delicate, and expensive—far too much so for the amateur or individual who would like to "roll his own."

The third method, and the one we are going to discuss, has some unusual advantages over the conventional systems. This method, namely, magnetic recording, is an entirely new system based on the principles employed in the magnetic wire recorder as developed in our laboratories. For those who might not be too familiar with magnetic recording, we might briefly review the basic principles of magnetic recording on wire, and then see how these have been applied to magnetic recording for motion picture film.

Let us start with the bi-polar type of magnet, which may take the form of a straight bar as in a compass needle, or a horseshoe magnet as in a magneto. These magnets have two poles — a north and a south. An invisible magnetic field surrounds these two poles.

A long bar of good magnetic material can be magnetized so as to have three poles, or for that matter, any number of poles. One way of producing a multi-polar magnet is to touch successive points on the bar to an ordinary horseshoe magnet. A multipolar magnet of this kind is basically a magnetic record.

If we substitute an electro-magnet for the horseshoe permanent magnet and a strand of wire for the bar, every time current is sent through the winding the electro-magnet is energized, and poles will appear on the wire. Each time the wire moves a new succession of poles is recorded. In this manner we can record telegraph signals on the moving wire merely by operating a key.

Now, in order to record sound, we energize the recording magnet with a microphone. The variations in magnetic field will not be sudden and discontinuous as with the telegraph key, but will vary smoothly and continuously according to the sound pressure in the microphone.

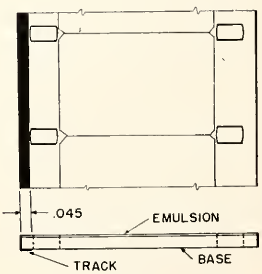
Having made our magnetic record on a steel wire, we may wind it up and store it on a spool. On the playback, the wire touches the pole-pieces of an electro-magnetic pickup, which may be identical in construction with the recording magnet. As the wire moves across the pickup, the tiny poles of the magnetic record induce a voltage in the winding. This voltage in turn is amplified and translated into sound by a speaker. The magnetic poles are not "used up" when the wire is played back. The magnetism is truly permanent, and the record may be played thousands of times.

The wire may be cleared by passing it through a high-frequency erase coil. The old record is erased, and the wire is now ready for a new one. Thus the wire may be used over and over again.

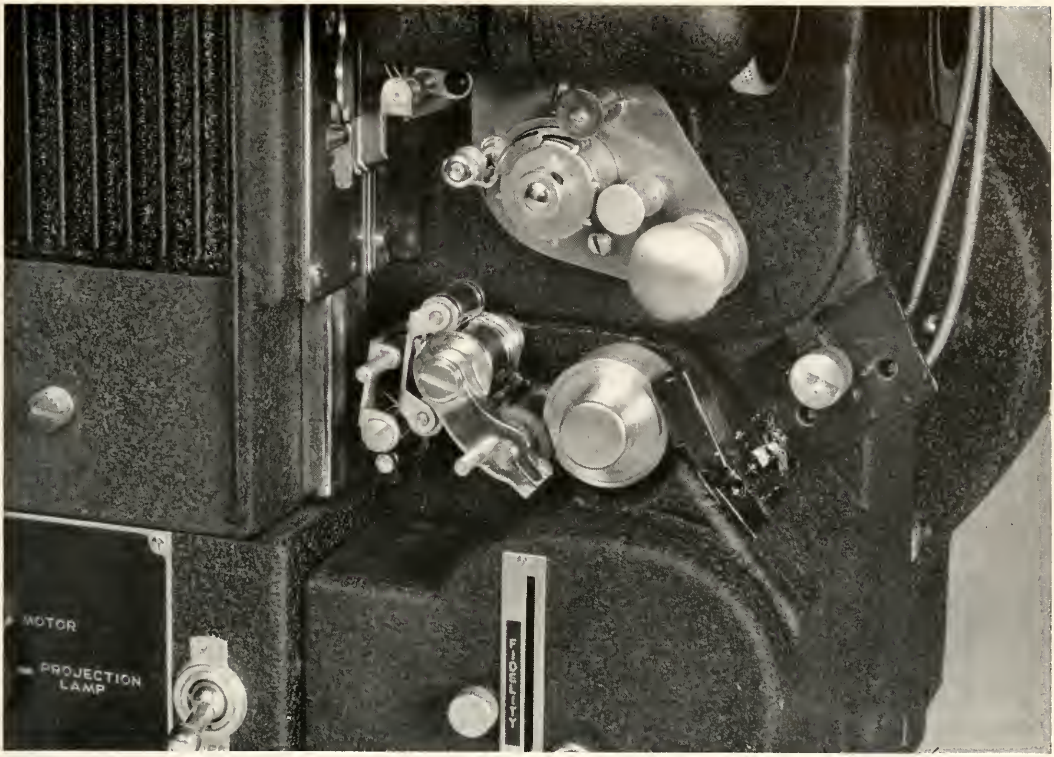
Instead of a round wire, the record may be modified to take the form of a flat tape or ribbon. This ribbon may be of solid material, or it may take the form of a metallized coating on a paper or plastic base.

In order to successfully apply a magnetic track to motion picture film, a superior magnetic material must be used because of the low speeds and narrow track.

Recently a special high coercive magnetic material has been developed, which can be bonded into the film stock. Measurements of magnetic properties indicate that a coercive force of 350 oersteds and a remanance of 500 gauss or more can be obtained in the finished product. These characteristics are obtainable with magnetizing fields of 1000 or below; thus the record can be erased quite readily. A number of other high coercive alloys were tried and found to be very difficult to erase. This new material has a fine grain size of a micron or less. It is not affected by photographic solutions, so that magnetic sound can be recorded simultaneously with the picture, or can be put on afterwards.



STANDARD 16 MM FILM WITH SINGLE MAGNETIC TRACK



Magnetic head mounted on Eastman Model FS-10-N projector.

Magnetic tracks can be incorporated into the film in a number of ways. We have produced a film which has a magnetic track .045 inch wide and .0005 inch thick coated on the back of ordinary sixteen millimeter film, which would travel through the projector at the standard sound speed of thirty-six feet per minute.

Although the coating makes the film thicker on one edge than the other, we have experienced no difficulty in reeling. To insure symmetry we could coat the other edge with an equal thickness of "blank" material, or we could put an additional track on that edge. The extra track could be used for a binaural system, or for special sound effects. It might also be used for control purposes, or for recording remarks or memos while editing the film. Perhaps the original recording might be made on one track and left intact, while the other track would be the final one, complete with background music, narrative, sound effect, etc. The amateur might of course have one sound track which he used for "public" demonstration, and another one with choice remarks for private showing.

Instead of placing a track on the outside of the film, we can use 16-mm sound film and locate the track on the unsprocketed side. This allows a wider track and gives increased fidelity. There is nothing to prevent adding a second track to this type of film also.

The magnetic head used with our present system is spring-pressed against the film while it rides on the flywheel stabilizer. Such a head can be added to conventional projectors with a minimum of trouble. The steadiness of the recorded signal will of course depend on the quality of the mechanical system, and a projector should be chosen with a sufficiently good drive for the purpose. By putting sound on after the film is processed, we can eliminate the flutter and wow that are caused by shrinkage, warping, or printing errors.

If the mass of the head is kept small, the spring pressure necessary to insure good contact is very light. Calculations for a typical case indicate that a force of only 1/1000 of an ounce is required. Because such low pressures are necessary, and because of the relatively large area of head contact with the film, wear problems are minimized.

The magnetic head mounted on an Eastman model FS-10-N projector is shown. By switching circuits the same head can be used for erasing, recording, or playback. The optical sound system need not be disturbed. In fact we have played the optical sound track on the right hand edge of a 16-mm release, and simultaneously recorded the sound magnetically on the left-hand edge. We thus had a film with two tracks, one magnetic, and the other optical. A more elaborate system

See ARF on page 50

Safety

HOME IS NO HAVEN FROM HARM

By E. Clark Woodward

To most people, the word "home" is emotionally associated with peace, well-being, and safety. Our language is replete with platitudes and phrases that foster such secondary meanings of the word. We say, "Home, Sweet Home," and "Home, at last," or we refer to the scoring base of a baseball diamond as "Home." When we complete a journey, we send a telegram to announce that our perils are over and we are "safe at home."

Perhaps our race memories hark back to the times when home offered security from the marauders and cutthroats of the streets and highways; when doors and windows were heavily barred and home was a private fortification. If so, it is high time to bring our thinking to a more modern level and realize that today we encounter peril inside as well as outside the threshold.

Accident statisticians, unswayed by emotional prejudices, look upon the American home as a decidedly poor haven from harm. National Safety Council reports show that some 32,000 lives are lost and at least 5,000,000 people are injured annually in home accidents. Quite possibly, the injury toll is even greater. Few people report the fact when they apply a bandaide to a scratched finger, so statistical estimating must take the place of facts. Hair splitting is, however, not required in order to make a strong case against the safety of the home.

By applying a system of cause analysis to the available hospital records and vital statistics, the accident statisticians have found that home accidents follow a clear pattern from year to year. Special studies have been made of data accumulated by the U. S. Census Bureau, The American Red Cross, insurance companies, and other interested agencies. In 1933 and 1934, a total of 4,602 home accident cases was analyzed at Cook County (Illinois) Hospital. Since there has been little change in the design and layout of homes since that time, the study still has significance.

Falling is universally the chief hazard of the home. Incidentally, a majority of all accidental injuries are caused by falls, regardless of the location of the accident. In the Cook County Hospital's 1933-34 study, for example, about two-thirds of the accident patients had been injured by falls. Of 2,146 fatal cases recorded between 1938 and 1940, the percentage of falls was slightly greater.

Further analysis brings to light facts regarding home falls that may be of value in accident prevention through improved home design and layout. Of the total falls, about one-third occured upon stairs or steps, another one-third at locations inside the house, and the remainder were outside the dwelling.

Stairway falls are severe. Many of them may be traced to mechanical or structural hazards. For example, a winding or circular type of stairway can never be truly safe. Straight flights of stairs, plus level landings, are far less hazardous. Uneven, broken, too shallow, too deep, slippery, or irregularly spaced stair treads have sent many a householder to a hospital fracture ward. Lack of handrails has done the same thing. Many home falls take place on the front or main stairway, but the worst offender is the rear or basement stair which has been poorly constructed, is poorly lighted, and often lacks handrails.

Mechanical shortcomings may contribute to falls in other home areas. Irregular surfaces, insufficient headroom, doors which swing in an unsafe direction, low window sills, storm windows which can be installed or removed only with difficulty, slippery surfaces, unsafe step ladders, and a host of other traps for the unwary all add to the total number of falls. Contrary to popular belief, not many of the falls recorded by Cook County Hospital occurred in bath tubs.

Burns, scalds, and explosions are second only to falls as sources of home injuries. From the standpoint of severity, they actually stand higher and are more likely to result in death. Although the available statistics include burns suffered in dwelling fires, the vast majority of the cases reported are in other categories. Steam, hot water, and other liquids — usually in the kitchen—account for the greatest number of burned householders. However, hot pipes, stoves, and radiators take a goodly share of the victims. Burning gasoline, naptha, and other flammable cleaning agents account for many fatal or otherwise severe burns.

So far, we have been discussing injuries which usually can be prevented by better design or layout of the home. There are many other causes which are, unfortunately, typical of the average home situation. Disorder or unsafe arrangement, improper equipment, improper use of otherwise safe equipment, lack of needed repairs, ice on sidewalks, lack of sufficient light—all contribute to the problem.

There are, of course, many instances of injury resulting from poor judgment, recklessness, heedlessness, and similar human shortcomings. However, it is a mistake to take a fatalistic

See SAFETY on page 44

ONE OF OURS

A Scholar and the World of Books.

Margaret Mann

With the World's Columbian Exposition held in Chicago came the realization that this event was ushering in the beginning of a new era. The glistening white, neoclassic temples on the lake front of Chicago housed new wonders in the way of scientific achievement. An inspired teacher, Dr. Frank W. Gunsaulus, had recognized the signs even before this exposition and had interested a great businessman, Philip D. Armour, in the founding of a college that would offer to the young men and women of the middle west an opportunity to pioneer in these great things to come.

In his prospectus for the college, Dr. Gunsaulus wrote, "It is the design of Armour Institute to educate the hand, the head and the heart. Knowledge, skill and culture are three constituent elements of a liberal education, and their attainment by the student is provided for through an adjustment of all the resources of the Institute."

This wise educator brought to his college outstanding leaders to carry forward his plan. The departments of the new college were outlined and among them was one in which this college was to pioneer in the middle west—the Department of Library Science. As conceived by Dr. Gunsaulus, this department was not to be a degree-granting course, but in the words of the prospectus, "The constant demand for trained assistants in libraries has led the Institute to establish library classes. The only places where systematic instruction of this kind is given are the New York State Library School in Albany. The Pratt Institute Library Training Classes in Brooklyn, the Drexel Institute Library Classes in Philadelphia, and the Los Angeles Public Library Class. The Armour Institute course is based upon the experience of these pioneers in the work."

The initial course of instruction in the Department of Library Science offered the prospective students a first year of basic study with the prospect of two additional years in advanced and comparative work. Miss Katherine Sharp, Ph.M., B.L.S., already well known for her library work, was appointed the first director of the department, and was assisted by Miss Jessie Van Vliet and Mrs. Julia Beveridge as assistant librarians. The first class began September 14th, 1893. The prospectus treated this department in the same fashion as the engineering departments.

Miss Margaret Mann, born in Cedar Rapids, Iowa, had recently graduated from Englewood High School in Chicago. Armour Institute was offering to Miss Mann an opportunity to develop those abilities which were to carry her far in her chosen field. A well-planned course of study, and real admiration for her teacher, Miss Sharp, made these college years go by only too fast. Miss Mann tells us, "The students at Armour Institute Library School were alive to new problems and were allowed to study new problems in the community which would lead the oncoming young people to realize what books could do for them and others." Her deep interest in her chosen profession is indicated by the record of straight "A's" in her college work.

Miss Mann, speaking of the courses offered in her department said, "Professors of the Institute gave lectures on the selection of books in their special fields. One of the advantages at Armour was the contacts to be made with scholars who were always interested in the library." Library science students, as practice work, established home libraries in Chicago. These were much appreciated by the communities that they served. The fact that the library school was in a large city allowed Miss Sharp to make the most of such large libraries as the John Crerar, the Newberry, and the library at the Chicago World's Fair. Their staffs were much interested in the new school and did much to further its success. There were also trips to various libraries in the territory surrounding Chicago.

Miss Mann received her certificate for her basic study in 1894 and went on to receive her diploma for advanced work in 1896. Dr. William Warner Bishop, Librarian Emeritus of the University of Michigan library, wrote of Miss Mann as he first saw her as a student at Armour, "She was easily first in a very brilliant group."

Miss Mann, after her graduation, was offered, and accepted, the opportunity to teach in the library school and then worked further in this field by teaching at summer sessions of the University of Wisconsin. In 1897, the Department of Library Science of Armour was transferred to the University of Illinois. Miss Sharp was to carry on her work at the University and she called upon her friend, colleague, and former student, to assist her in this new venture. Miss Mann was appointed an assistant on the library staff of the University and an instructor in the library school. In

See MARGARET MANN on page 46

Notable Books of 1946

This selection from the more than 7500 books published during the past year is largely a compilation from the lists of "notable" books published in December in the Chicago *Sun*, the Chicago *Tribune, Time,* and *The Nation.* A few books have been added by the compiler because he felt that they had been overlooked by the selectors.

Harvey Curtis Webster

FICTION

Aleishem, Sholom. *The Old Country.* N[2]

Asch, Sholom. *East River.* CS[1] T[3] CT[4]

Bernanos, Georges. *Joy.* T N

Best Short Stories of 1946. Edited by Martha Foley.

Bowen, Elizabeth. *Ivy Gripped the Steps.* T N

Camus, Albert. *The Stranger.* N

Dreiser, Theodore. *The Bulwark.* T CT

Goodman, Paul. *The State of Nature.*

Howe, Helen. *We Happy Few.* N

Isherwood, Christopher. *The Memorial. The Berlin Stories.*

Jackson, Charles. *The Fall of Valor.* T CS BS[5]

Kafka, Franz. *The Great Wall of China. Metamorphosis* N

Kavan, Anna. *Asylum Piece.*

Koestler, Arthur. *Thieves in the Night.* T CS BS N CT

La Farge, Christopher. *The Sudden Guest.* N CT

Marquand, John P. *B. F.'s Daughter.* T CS BS

Maugham, W. S. *Then and Now.* T BS CT

Mauriac, Francois. *Woman of the Pharisees.* T N

McCullers, Carson. *The Member of the Wedding.* CT

Nin, Anais. *Ladders to Fire.*

Pen, John. *Temptation.* CS

Petry, Ann. *The Street.* N CT

Remarque, Erich. *Arch of Triumph.* T BBS[6]

Richter, Conrad. *The Fields.* T CT

Schmitt, Gladys. *David the King.* T BBS N CT

Shaw, Irwin. *Act of Faith and Other Stories.*

Simenon, Georges. *The Man Who Watched the Trains Go By.*

Sinclair, Jo. *Wasteland.* BS

Stead, Christine. *Letty Fox.* T

Tabori, George. *Companions of the Left Hand.* T

Wakeman, Frederick. *The Hucksters.* T BBS

Ward, Mary Jane. *The Snake Pit.* BS CT

Warren, Robert P. *All the King's Men.* T CS BS N CT

Waugh, Evelyn. *Brideshead Revisited.* T BBS

Weidman, Jerome. *Too Early To Tell.* T

Welty, Eudora. *Delta Wedding.* T CT

Werfel, Franz. *Star of the Unborn.* T

Wilson, Edmund. *Memoirs of Hecate County* CS N

POETRY

Andrade, Jorge Carrera. *Secret Country.*

Aragon, Poet of the Resistance. Edited by Malcolm Cowley and Hannah Josephson.

Bishop, Elizabeth. *North and South.* T N

Cummings, E. E. *Santa Claus: A Morality* T

Graves, Robert *.Poems: 1938-1945.* T N

Jeffers, Robinson. *Medea, Freely Adapted from the Medea of Euripides*

Kreymborg, Alfred. *Man and Shadow.*

Lowell, Robert. *Lord Weary's Castle.* T N

Manifold, John. *Selected Verse.* T

Thomas, Dylan. *The Selected Writings of.* T N

Vasakas, Byron. *Transfigured Night.*

War and the Poet. Edited by Selden Rodman and Richard Eberhart.

Williams, William Carlos. Paterson (Book One) T N

MISCELLANEOUS

Adamic, Louis. *Dinner at the White House.* T

ARNALL, Ellis. *The Shore Dimly Seen.* N

Beard, Mary. *Woman As A Force In History.* N

Benedict, Ruth. *The Chrysanthemum and the Sword.* N

Bentley, E. R. *The Playwright As Thinker.*

Benet, Stephen V. *The Last Circle.*

Burke, Kenneth. *A Grammar of Motives.*

Cecil, Lord David. *Thomas Hardy.* T CT

Cohen, Morris. *The Faith of a Liberal.* N CT

Connelly, Cyril. *The Condemned Playground.* N

Dewey, John. *Problems of Men.* N

Dorfman, Joseph. *The Economic Mind in American Civilization* (1606-1865) T N

Des Passos, John. *Tour of Duty.* CT

Evans, Bergen. *The Natural History of Nonsense.* CS

Gregory, Horace and Zatursenska, Matha. *A History of American Poetry: 1900-1940.*

Halsey, Margaret. *Color Blind.* N CT

Hersey, John. *Hiroshima.* T N CT

Hicks, Granville. *Small Town.*

Isherwood, Christopher (editor). *Vedanta for the Western World.*

See BOOKS on page 60

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[1] Selected by the Chicago *Sun.* [2] Selected by *The Nation.* [3] Selected by *Time.* [4] Selected by the Chicago *Tribune.* [5] A national best seller. [6] A Big Best Seller.

University Conference On Corrosion And Metal Protection

The list of speakers for the University Conference on Corrosion and Metal Protection, which is to be held at the Museum of Science and Industry, in Chicago, in a three-day session on June 11, 12, and 13 has almost been completed. This announcement was made by the chairman, Hugh J. McDonald, Illinois Institute of Technology and vice-chairman, Mars G. Fontana, Ohio State University. An outstanding selection of subjects by leading men in the field is promised. The opening address will be given by Henry T. Heald, President, Illinois Institute of Technology. The technical papers will be of a quantitative and research character, and will emphasize the science background of corrosion rather than the art of corrosion testing and practice. As each speaker is being allowed about an hour for presenting his talk and for discussion, there should be sufficient time to go into the various subjects in more detail than is feasible at the usual scientific meeting. The slate of speakers and the titles of their talks are arranged alphabetically below:

Carl W. Borgmann, University of Colorado; Bi-Metallic Corrosion.

A. L. Ferguson, University of Michigan; The Mechanism of Overvoltage Phenomena.

Mars G. Fontana, Ohio State University; Surface Studies of Metals from the Corrosion Standpoint.

Norman Hackerman, University of Texas; The Role of Adsorption from Solution in Inhibitor Action.

Cecil V. King, New York University; Kinetics of the Dissolution of Metals.

Charles A. Mann, University of Minnesota; Some Concepts of the Mechanism of Corrosion Inhibitor Action.

H. A. Miley, Air Technical Service Command, Watson Laboratories, Cambridge, Massachusetts; Oxidation, Tarnishing and Surface Films of Metals.

Thomas C. Poulter, Armour Research Foundation; Mechanism of Cavitation Erosion.

C. F. Prutton, Case School of Applied Science; The Corrosion of Bearings.

R. L. Starkey, New Jersey Agricultural Experiment Station; Bacteria and the Corrosion of Iron.

Michael A. Streicher, Lehigh University; Corrosion Protection by Phosphatization.

H. H. Uhlig, Massachusetts Institute of Technology; Adsorbed and Reaction-Product Films on Metals.

James T. Waber, Illinois Institute of Technology; Generalized Theory of Stress Corrosion Cracking.

W. H. Zinn, Argonne National Laboratory; Corrosion and Atomic Power.

The conference is being sponsored by the following institutions, all of which are now actively engaged in work on corrosion and metal protection: Carnegie Institute of Technology, Illinois Institute of Technology, Lehigh University, Massachusetts Institute of Technology, Ohio State University, and the Universities of Chicago, Colorado, Minnesota and Texas. Everyone interested in the fundamental aspects of corrosion is invited to attend and to participate in the discussion.

THE SCHOOLMASTER

Monuments. To most Americans the word is likely to suggest the shaft that carries Washington's name, or the Lincoln Memorial. But there are monuments that are not obelisks nor white marble buildings. A monument is a reminder, a symbol of recognition of character or achievement, an indication of appreciation of a man or an event. There is a temptation to extend the meaning of the word, and to say that a monument may be not a material thing. "Well done." That's Navy talk. A perfect pair of syllables. Perfect appreciation.

"If you seek his monument, look about." Sir Christopher Wren's epitaph in St. Paul's in London could serve for many another architect whose memorial is a great and beautiful building. What monument to Roebling could be so appropriate as the Brooklyn Bridge? But not every noble structure can bring to mind the name and personality of the man who conceived it. Do we know who were the architects of the Twelfth and Thirteenth Century Gothic cathedrals?

Chicago developed the sky-scraper. The earlier high buildings were on foundations not far below street grade, comprising thick slabs of concrete with embedded steel beams; these "floating" foundations covered all or nearly all of the lot area, so that the unit load transmitted to the soil was kept below what was considered a proper maximum. As the number of buildings increased, and as subways and other underground works were undertaken, settling of the great concrete "rafts" developed. The buildings were then made safe and stable by sinking shafts to hard-pan or bed-rock and pouring concrete to form subterranean columns, several feet in diameter, and scores of feet in vertical dimension, to carry the weight of building and contents; the work was done without inconvenience to occupants of the buildings, usually without their knowledge. Perhaps these concrete caissons are monuments, but they are not now visible; many of them will never be seen.

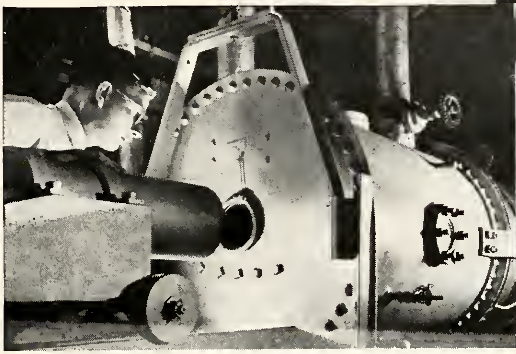
See SCHOOLMASTER on page 54

Du Pont *Digest*

Items of Interest to Students of Science and Engineering

Explosives—an essential industrial tool

A. L. St. Peter, Princeton '37, supervisor blasting operation Susquehanna River Project, lowers a 5½ inch "Nitramon" Primer into one of 600 drill holes preparatory to blasting a pipe line ditch.



Frank A. Loving, Chemical Engineer, Texas A & M '41, prepares to fire an explosive charge into a chamber of methane or dusty air to test safety under conditions found in coal mines.

INDUSTRIAL explosives are as much of a yardstick of industrial progress as sulfuric acid. They are involved in the fabrication of nearly all the products used by man. This year the United States will use over 500 million pounds of industrial explosives.

The technical problems that confront the explosives industry are many and varied. A measure of this is the fact that the Du Pont Company manufactures about two hundred dynamite formulations, each intended to do a different job, from the slow heaving action of blasting coal to the rapid, violent shattering necessary for a hard ore. Ranging between these two extremes are a large number of intermediate grades, including explosives especially formulated for agricultural work, seismic prospecting for oil, submarine blasting—right down to the tiny charge used in an explosive rivet.

Studies in Laboratory and Field

One of the first industrial laboratories for chemical research in the United States, the Eastern laboratory of the Du Pont Explosives Department has nearly two hundred chemists, engineers, physicists and assistants. There, methods have been developed for measuring the power of explosives, the degree to which they shatter or pulverize various materials, their water resistance, their safety characteristics when exposed to shock or flame, the composition of the gases they produce, etc. As a result of studies of the influence of various factors on dynamite performance, it has become possible to formulate an explosive to meet practically any blasting condition.

In keeping with these improvements, the application of explosives has reached a new level of efficiency. Technical service men, usually mining engineers or civil engineers, aid consumers in the selection and use of explosives. They also work closely with research men in solving unusual problems encountered in the field.

Research—Path to Progress

A few of the results gained through research are: (1) lowering of dynamite freezing points by nitrating ethylene glycol along with glycerol to diminish the hazards of thawing frozen dynamites. (2) Production of less hazardous dynamites by substituting ammonium nitrate partially for nitroglycerine, in spite of the greater hygroscopicity and lesser explosive power of the former. This resulted in dynamites less hazardous to manufacture and use. (3) Introduction of "Nitramon," a blasting agent containing a high percentage of ammonium nitrate as its major ingredient. It is equal in strength to the most powerful dynamites commonly employed and yet is by far the safest blasting agent available. (4) Development of explosives with a minimum of noxious gases for use in confined areas. (5) Numerous improvements in the composition, manufacture and design of the blasting caps which set off the main charge.

Aside from these developments in explosives and blasting supplies, there have been many accomplishments in chemistry and engineering associated with such projects as the oxidation of ammonia to nitric acid; manufacture, granulation and drying of ammonium nitrate; substitutes for nitroglycerine and ethylene glycol dinitrate, concentration of nitric and sulfuric acids, and a host of other subjects.

Questions College Men ask about working with Du Pont

WHAT ARE THE OPPORTUNITIES FOR RESEARCH MEN?

Unusual advantages in facilities and funds are available to men qualified for fundamental or applied research. Investigation in the fields of organic, inorganic and physical chemistry, biology, parisitology, plant pathology and engineering suggest the wide range of activities. Write for booklet, "The Du Pont Company and the College Graduate," 2521 Nemours Building, Wilmington 98, Delaware.

DU PONT

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BETTER THINGS FOR BETTER LIVING
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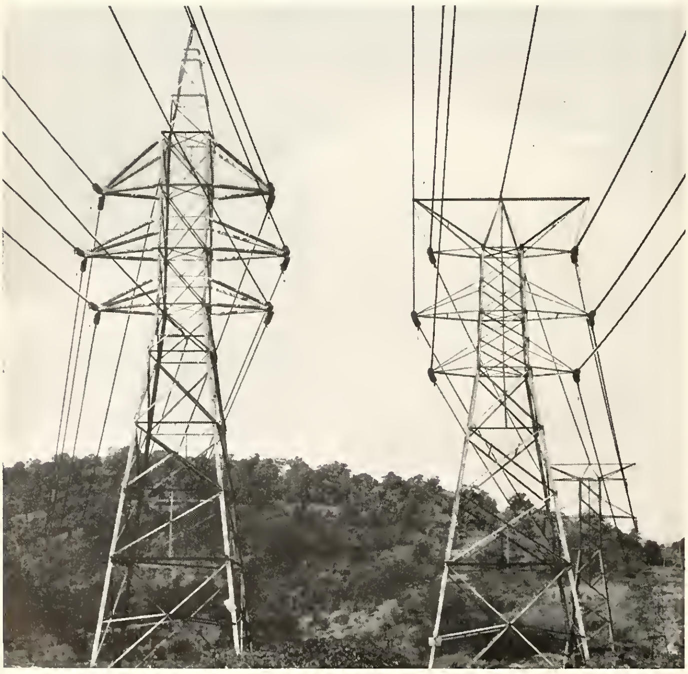
(Continued from page 18)

immunity to lightning. Figure 2 shows a comparison of the rebuilt line on the left with an adjacent line of the old construction on the right. Supplementary tower-footing grounding methods were employed which reduced tower-footing resistance in most cases. This figure was furnished by Mr. E. W. Oesterreich, General Superintendent of Distribution, Duquesne Light Company, who reported on the performance of the rebuilt line at the recent Midwest Power Conference.

In this design, the voltage appearing across the insulation between conductor and tower was limited by use of the elevated shielding ground wire, an "underline" coupling ground wire and supplementary grounding electrodes close to the tower base. The low footing-resistance reduced the tower potential appearing as a result of the product of lightning current and tower footing-resistance, while the increased coupling afforded by the underline ground wire increased the conductor potential, thereby minimizing the potential difference across the insulation. The insulation offered to impulse voltages was greatly increased by replacing the old steel arms with wood arms. Prior to rebuilding, this important 24.4 mile line averaged 3.4 single circuit and 4.6 double circuit to make a total of eight lightning tripouts per year. Over the period from 1941 through 1946 after rebuilding, this line averaged 0.83 single circuit and no double circuit tripouts per year. It may be of interest to compare the last figure with the final design estimate of 0.71 average tripouts per year based upon published data from over 2700 lightning current measurements and the distribution curve of tower-footing resistances as measured after installation. Although the closeness of these figures is doubtless a matter of chance, it is believed that with proper care reasonably good predictions of line performance can be made. Outage-free performance has been reported for well-designed high voltage lines where earth conditions permit tower-footing resistances under 10 ohms.



Modernized 66 kv transmission line employs the unusual feature of an underline ground wire. Construction before modernization is shown on the right.

FUTURE WORK

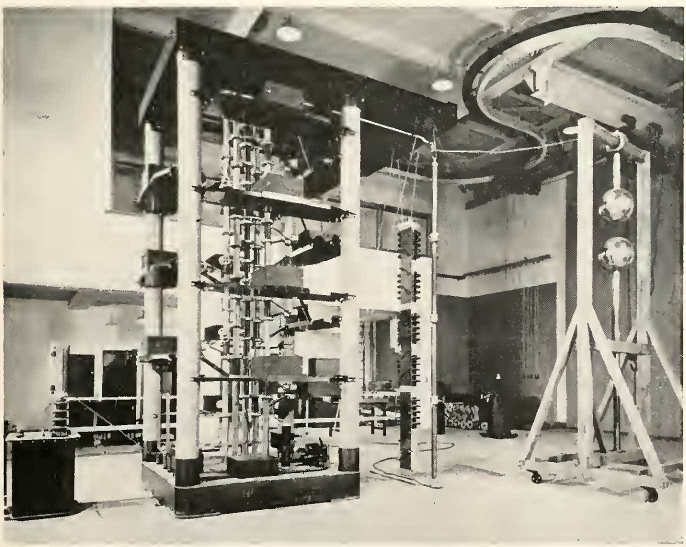
It is natural that stress should be laid upon the successes that have attended the application of the research method to a major power system problem, since ultimately it is results which count. On the other hand, there are still many opportunities for the student of power engineering to contribute to the solution of the lightning problem. Much remains to be learned about the impulse breakdown characteristics of insulating materials subjected to impulses less than one microsecond in length. There is also room for improvement in the protective characteristics of lightning arresters. While the impulse breakdown characteristics of many types of porcelain insulator, alone and in combination with wood supporting members, have been ivestigated, many flashover paths involve porcelain, wood and air in series for which few if any data are available. Electronic oscillographs and their associated measuring circuits can be improved and standardized. Much of this fundamental work can and is being done at laboratories of educational institutions. Figure 3 shows the modern impulse generator in the high voltage laboratory of the Technological Institute at Northwestern University.

For those who prefer analysis, there are still opportunities for contribution to the study of the various voltage components which appear on a transmission line as a result of both direct and near-by lightning strokes. In this connection the whole problem of the transient impedance offered by the supporting structures and their grounding systems can stand further study.

Closely associated with the electrical and physical problems of lightning protection are the statistical and economic phases which are assuming in-

creasing importance and which are receiving more attention as the physical problems are solved. The striking reductions in service interruptions and apparatus damage which have been effected in the past ten to fifteen years have resulted in fundamental changes in the philosophy of system design so that emphasis is now being placed upon equipment availability rather than on spare capacity. There is a future for the young engineer who can couple his knowledge of electrical engineering with the science of statistics and probability so that he is equally at home with the kilowatt, the kilovar, and the dispersion of n-year average of customer service interruptions!

Concluding this brief review of the problem of lightning protection for electric power systems, we can look with some satisfaction at the success of the research approach which has proved so fruitful in the reduction of its findings to practical application. Future progress will demand clear analysis of both electrical, statistical, and economic problems. There can be no doubt, however, that the young engineer will meet this challenge.



The new 1,500,000-volt impulse or "articificial lightning" generator at the Technological Institution of Northwestern University.
(Photo by courtesy of Northwestern University)

ROCKET RESEARCH

Modifications of methods of measuring the blazing heat of distant stars and the speed of rotation of the sun have been adapted by scientists of the General Electric Company to a research program designed to create rockets that will outperform the German V-2.

By study of the wave lengths of molecular radiation, physicists of the G-E Research Laboratory take the temperature of rocket gases too hot to measure by conventional methods.

Using a method by which astronomers measure the speed of rotation of the sun, scientists can compare the velocity of the superheated gases with the velocity of light, thereby determining the speed of the flames as they blast from the rocket motor. This speed is generally greater than 6000 feet per second or six times the speed of sound. In this way, measurements could be made of velocities almost as great as the speed of light itself, 186,000 miles a second.

Dr. R. W. Porter, engineer in charge of the extensive G-E rocket-research program being conducted for the Army Ordnance Department, announced today that Dr. Francis P. Bundy and Dr. Herbert M. Strong, research physicists, had developed the methods of measurement to a point where reasonable accuracy could be expected.

Dr. Bundy, formerly with the Harvard Underwater Sound Laboratory, who has been conducting experiments relating to the speed of the rocket gases, stated that the "Doppler effect," by which the speed of an object toward or away from a certain point can be measured, is the basis of his tests. A common example of the "Doppler effect" is the whistle of a moving train which seems higher pitched when approaching than when moving away.

By means of two periscopes, looking at an angle into the rocket jet, the wave length of the radiation from sodium atoms in the flame is recorded on photographic film. The apparent wave length of atoms moving away is recorded through one periscope; the

See ROCKET on page 60

(Continued from page 19)

having some effect and with more pressure from better trained and equipped librarians to offer or require such courses, some provision may be more generally developed in the future.

Engineering, except in special cases, such as government work, must produce a profit. Engineering is a dominant part of our industrial organization and competition is severe and ruthless. Although the fundamental laws on which all work is based are constant, modern design must always reflect an improvement over existing thoughts or equipment. The fact that engineering is so closely dependent upon our economic structure, and that its motive is so predominantly for profit, greatly affects publications in the fields of engineering literature.

Much of the research done by a private individual is not written for publication. There is no reason for an engineer to rush into print with the latest invention or design except for advertising purposes and then only the final result is discussed and not the method of accomplishing it. Much of the criticism for this lack of publication is not justified since an article written by an employee of any of our big, modern engineering companies such as DuPont or General Electric, must be approved by their engineering, publicity and legal departments before it can be put into print. The questions of who are the writers of engineering publications may well be expressed in the differences of their type of employment—that is, the employees who are further removed from private gain are those who write most freely.

This is one reason why so many new engineering achievements are presented to the world as accomplished facts with no advance publication of new principles involved. This policy holds true in times of peace as well as war. Only the engineering librarian realizes intensely that the situation exists when he gets repeated requests for information wherein the inquirer insists that he knows that the work is in progress and cannot understand why it is not available in print in the library. Herein lies one of the major differences between science and engineering.

In a recent survey sponsored by the Carnegie Corporation, the libraries of thirty technological institutes of various types were found to be on the whole neglected, having unsatisfactory quarters, with small budgets for books and periodicals and with staffs much too small to handle adequately the heavy burden of routine work, with a resultant confusion in the records due to a lack of trained supervision and adequate central control. Librarians of technological institutions are generally above the average in ability and alertness and certainly are hard working but their staffs are much too small to handle adequately the heavy burden of routine work and give the supplementary service a student has the right to expect.[1] Even larger and stronger institutions usually have small budgets for the purchase of books and periodicals and a comparison of expenditures shows that liberal arts colleges spend 1.97 per cent of their total institutional expenditures for the purchase of books and periodicals and technological colleges only .785 per cent. Another more recent survey of eighteen engineering school libraries in the Middle Atlantic states shows a similar percentage for library expenditures with evidence that as a rule books and periodicals rather than salaries received the bulk of these limited budgets.

Standard text books and important periodicals are the basic sources of any library in providing a complete, sure, and up-to-date source of knowledge of the status of engineering and related sciences. However, engineering libraries find that while books form the background of what has been accomplished, since they present in permanent form generally accepted theories and facts which often have appeared in periodical publications at an earlier date, in the fields of active development such as science and technology, periodials which provide the most important sources of current information have pushed the book into the background. The result is that the strength of such a library is more effectively measured by its periodical content than by the size of its book collection, and the kind and number of current subscriptions to current periodicals are of more importance than the inclusion of complete sets of only a few titles. The Illinois Institute of Technology library, for example, receives some 700 periodicals currently, about 500 of which are bound for the permanent collection.

Books in a technical library have become of secondary interest, not only for the fact that due to the time elements necessary for writing, publishing and distributing they necessarily lag behind current knowledge, but also because with the exception of a comparatively few classics, their use is chiefly for instruction and for quick reference. In the past, books in engineering fields have been little more than texts of a limited appeal providing elementary fundamentals and description. Few engineering books are read through from beginning to end and they are used chiefly as sources of information on specific subjects. For this reason most technical books are equipped with well-worked out indexes and it logically follows that to make the most effective use of these books it is necessary to provide not only more, but more specific subject entries in the card catalog to make their contents readily available. Recently a new and better tendency in technical writing and publishing has developed as the profession as a whole has become aware that its activities rest upon scientific foundations and depend upon related fields for their development, and improvement and durability of engineering literature is the result.

We constantly hear that our scientific and technical books lose their value more quickly than the average publications and certainly the need is almost always for the latest material, the older material being not only out-of-date but often technically wrong. Obsolescence in technical material is therefore very high and five years of

(Continued on page 36)

[1] Barcus, Thomas R. The Carnegie study of the libraries of technological colleges. *Journol of Engineering Education*, v. 32, 1942. p. 424-433.

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Television—a Season Pass to Baseball !

Every home game—day or night—played by the New York Giants, Yankees and Brooklyn Dodgers will be seen over television this season!

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Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

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- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to National Recruiting Division, RCA Victor, Camden, New Jersey.

Also many opportunities for Mechanical and Chemical Engineers and Physicists.

RCA **RADIO CORPORATION of AMERICA**

(Continued from page 34)

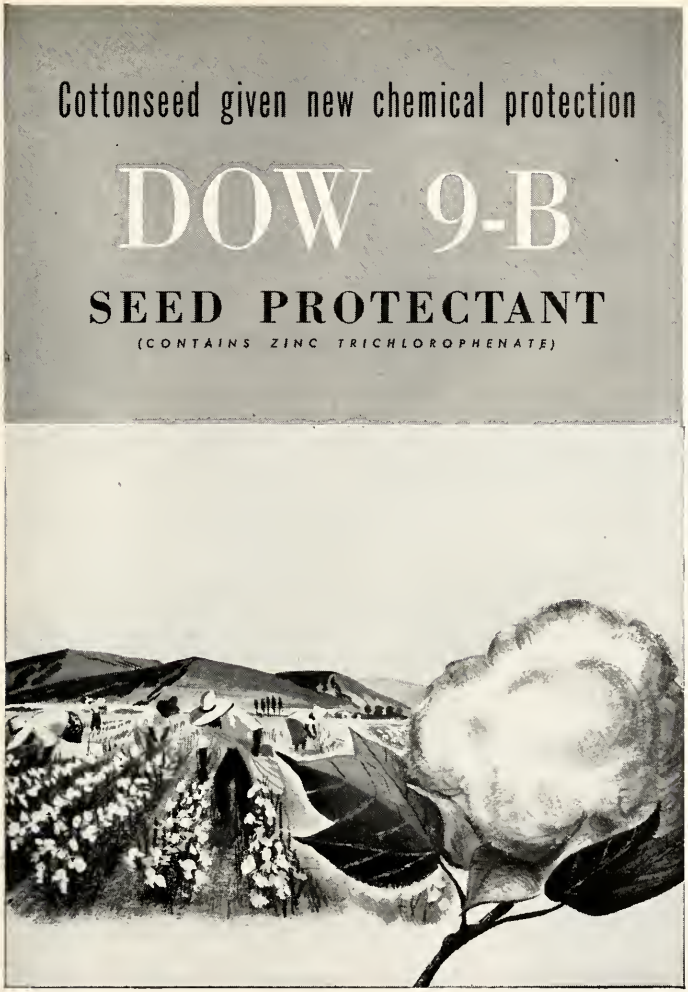
useful life is probably a fair estimate of the value of the average book. New editions of a title are also more prevalent and the eight editions of Johnson's *Materials of Construction* in forty-two years (1898-1939) is not an exception.

Quality rather than quantity would seem to be the best objective in the development of the collections in libraries attempting to secure the best and latest books and periodicals. Since "best" and "largest" are not synonymous, the goal might well be to have every item needed for the purpose of the specific collection and not a single item which cannot be justified by use. The annual output of new American scientific and technical books runs between 300 and 500 new titles, with over 100 new or revised editions. New technical and scientific books are usually bought immediately upon the publishers' announcements rather than waiting for the regular reviews which so often appear only months later, without a critical examination as to whether or not the material adds to information already available or whether the book is adequate and reliable in its information. Thus the usual book selection aids become checks rather than guides for buying. Such technical journals as *Science* and *Mechanical Engineering* carry information about new books in some form or other, but very few of them have any consistent or adequate program for providing this important information and complete bibliographical information if often lacking.

For these two reasons, the high obsolescence rate and the means used for selection, discarding from the collection becomes as important as acquiring in order to maintain not only adequate but useful book collections. There is not only the problem of providing the latest material but also that of keeping only the correct information since the literature is chiefly factual and descriptive rather than critical.

The staffs of engineering libraries have almost always been well under the average to be found in other libraries in size, training, and salaries. This is due not only to lack of interest on the part of administrators and faculty but also to the fact that the professional engineer has never been attracted by the lower salaries offered to librarians. It has generally been felt by the administrators that it is more satisfactory to teach a librarian the needs of the engineers than to attempt to teach an engineer how to operate a library. With the recent promotion of engineering libraries and the development of research, the staff personnel has been improved and increased generally, although much remains to be done. Older, more inbred

(Continued on page 38)



Tests Show Bigger Yield with Dow 9-B Seed Protectant

One of the chief concerns of Dow is to develop chemicals that protect and increase America's crops. Recently introduced by our Agricultural Division is Dow 9-B Seed Protectant. This product is used to disinfect cottonseed carrying seed-borne diseases and protect the seed and new seedlings against attacks from soil-borne bacteria and fungi. Tests of this material indicate bigger yields with less seed per acre.

Technicians and students especially attracted to agricultural chemistry will find much to interest them in this division of Dow where research is a continuous activity.

Industrial Chemicals • Agricultural Chemicals
Pharmaceutical Chemicals • Magnesium • Plastics

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CHEMICAL COMMENTS

Sprout Stopper

Ambitious potatoes don't like to stop sprouting, even when sprouting means loss of weight, food value and marketability. Chemists at Dow have produced a sprout inhibitor that really says *Stop!* Its use also means that potato storehouses can be kept warmer . . . potato sugar content stays lower . . . potato chips keep their blond complexions, sell better. It works equally well with carrots, turnips and other root crops. (Naturally, it's *not* recommended for seed potatoes.)

Plastic Insulation That's Lighter-than-Cork

Take a plastic—to be specific, take Dow polystyrene—air-expand it until it honeycombs into a rigid material that is even lighter than cork—and you have Styrofoam. It's winning new laurels in the low temperature insulation field because of its high efficiency, extremely light weight, good strength and excellent stability. This is the same Styrofoam used to advantage in boats and canoes, life rafts, beach toys and novelties. It floats, and *stays* afloat, because its millions of tiny air cells are individually sealed.

Caustic Comment: *Did you know that caustic soda—one of man's most widely used and sorely needed chemicals—is the pickling ingredient that takes the bitterness out of green olives?*

New Washable Plastic Paints

The wearable, washable characteristics of plastics are now given to new plastic paints. A tough protective film is formed by plastic particles that bond themselves together. The paint, made possible by a new product called Saran F-122 Latex, dries extremely fast into a long-enduring glossy finish. These paints may be applied with either brush or spray to wood, fibreboard, metal or masonry.

Whiffs and Puffs

Many a favored brand of pipe tobacco is being forsaken for the new tobacco mixtures with a tantalizing blend of maple-licorice plus a definite suggestion of walnut. Secret of the new flavor fillip is the Dow aromatic specialty, Cyclotene . . . one of many man-made aromatics bringing forth new scents and tastes in soaps, cosmetics, flavors and perfumes.

Further information on any of these chemical developments is available on request.

DOW

CHEMICALS INDISPENSABLE
TO INDUSTRY AND AGRICULTURE

(Continued from page 36)

institutions are slower and more reluctant to change and to admit the need for providing better libraries but even these institutions are feeling the need to develop their libraries in order to provide their faculties with facilities for continued research and study, and their students with material for preparation in writing reports and for reading outside of text books.

Much has been done in the past five years to improve not only the status of these libraries but their collections, service and staffs as well. In 1940, engineering school librarians organized sections within the American Library Association and the American Society for Engineering Education to promote a better recognition not only of their purposes and needs but also of the necessity of supplying this library service to engineers. The section of the American Library Association is interested in developing the standards of library service in engineering schools and that of the American Society for Engineering Education aims more towards a better co-ordination of the library within the curriculum, and the development of the teaching function of the library by more or less formal instruction in the use of the library facilities. A similar group within the Special Libraries Association constitutes the largest section numerically but its membership has more of an industrial background and is interested in the exchange of ideas and materials and techniques rather than the broader principles of development.

Thus, with the development of engineering literature, the awareness of the need for libraries in order to have this material readily accessible and to provide more instruction to engineers in the use of libraries and the proper procedures for library research, the prospect for better and more complete libraries with improved staffs and quarters seems hopeful. Their future development depends to a large degree upon the extent to which engineers themselves make use of library facilities.

GRADUATE SCHOOL

(Continued from page 15)

facilities. Knowledge of the physical universe must be based upon physical experiments, but many great strides have been made by analysis based on the experiments and laws developed by others. In this respect mathematical developments find their greatest usefulness. Obviously no college or university can maintain elaborate research laboratories in all its fields of endeavor. It must start with modest beginnings and add to its facilities as need arises and as conditions and finances permit.

Often the investigations of college laboratories and research workers are of direct interest to industry and may well find direct support from industry. The applied problems of immediate interest and commercial importance are usually best solved in industry or industrial research laboratories devoted to the immediate solution of specific problems. However, the long-term quest of new basic knowledge flourishes best in an atmosphere free from commercial urgency, where the path may be followed wherever it leads. In this respect the college laboratory is often the best if not the only means of conducting this type of research adequately. Progress in fundamental development is the best possible insurance of later industrial prosperity, as the fundamental developments of today lay the basis for new industries to come. The desirability of more adequate support for college laboratories and college research has been recognized by the federal government and particularly the armed forces which are currently assisting in the support of many research projects.

Although college laboratories, once established, provide facilities which may often be used advantageously for applied research projects, sight should not be lost of the primary purpose of college research activity, the improvement of advanced instruction. The results of the research should be made public, and in general the patents, if any, which result should be administered by the college in the public interest. Graduate students should be used in the work to provide training for them in the conduct of research, and usually some phase of the activity should be suitable for the student's thesis.

Research activity which does not conform to these general principles may be of the greatest value to industry or to the public generally, but it is no longer primarily part of the educational activity, and it may preferably be separated from the instructional departments into a separate department or separate institution altogether.

The Graduate School of Illinois Institute of Technology sponsors a number of specialized laboratories, although the active administration is under the direction of the corresponding instructional departments. Among these may be mentioned: the Catalysis Laboratory, studying petroleum products, in the Department of Chemical Engineering; the Corrosion Laboratory, studying the fundamental problem of corrosion, in the Department

(Continued on page 42)

This message originally appeared in the Trenton (New Jersey) Times Advertiser.

WHAT DO <u>YOU</u> SEE IN YOUR NEIGHBOR?

TRENTON BY ORIGIN is a crossroads—a community of people drawn together from the four corners of the earth by any one of a number of attractions.

Being a part of this growing neighborhood is a responsibility, for its interests are your interests—its friends, your friends—its enemies, your enemies.

There was a time when cities like Trenton were protected against attack by great walls and strong gates. Today's assailants cannot be kept out by such primitive methods. They come into our midst like invisible Trojan horses, and their only weapons are theories and glib tongues.

Disguised as friends, they reveal themselves only after they have assembled enough followers to attack from within; when it is too late for us to do anything about it.

Their methods are simple: They work with us, agree with our ideals, and sympathize with our troubles. When they have won our confidence, when they have succeeded in getting themselves appointed to committees, and elected to offices...they turn upon us. Like the amiable tourists, who suddenly donned enemy uniforms, during the last war, they attack when we least expect it...when we are helpless against them. They usually begin by labeling our time-tried leaders with names which insure their downfall—but which describe the intruders best—and having succeeded in ousting our leaders, they take over.

Is it too late to do what stone walls and strong gates could not do? Do we want these dangerous men in our country, in our clubs, in our unions, in our businesses and in our government?

Let the man who wants to hold office identify himself. Let the man who wants to live with us and work with us, reveal his purpose. Let the man who wants to have a voice in our affairs, disclose his ambitions and ideals.

It is our duty to know our neighbors. We only can trust them when we do. "Good fences make good neighbors" and good neighbors make good cities—good governments—good unions—good businesses—good citizens.

JOHN A. ROEBLING'S SONS COMPANY
TRENTON 2, NEW JERSEY

Manufacturers of Wire Rope and Strand • Fittings • Slings • Aircord, Aircord Terminals and Air Controls • Suspension Bridges and Cables • Aerial Wire Rope Systems
Electrical Wire and Cable • Hard, Annealed or Tempered High and Low Carbon Fine and Specialty Wire, Flat Wire, Cold Rolled Strip and Cold Rolled Spring Steel
Ski Lifts • Screen, Hardware and Industrial Wire Cloth • Lawn Mowers

(Continued from page 40)

of Chemistry; the Engine Research Laboratory, studying the problem of engine noise, and the Heat Transfer Laboratory, studying the general problems of heat transfer, both in the Department of Mechanical Engineering; the A-C Network Calculator Laboraotry, devoted to the study of electric power-system problems, in the Department of Electrical Engineering, and operated by the Armour Research Foundation; and the Electron Microscope Laboratory, in the Department of Physics. Other special equipment is also devoted largely to research.

The Institute welcomes industrial support for the conduct and expansion of its fundamental research activities, but retains the right of publication of the results after review, if requested, by the sponsors of individual projects. In general, patent rights also remain with the Institute, although royalty-free licenses may be granted to sponsors who have provided substantial support for individual projects. In special cases, if sponsors underwrite the entire research costs, patent rights may be assigned provided assurance is given that the patents will be administered in the public interest.

One form of support for research which has proved attractive is the establishment of research fellowships. The fellowship provides a stipend for the fellow, the tuition costs, and in many cases an allowance for special equipment which may be needed in the research. Frequently the fellowship is made available to employees of the company offering it, with the expectation that the successful candidate will return to the employ of the company after completion of his program. With the aid of such a fellowship the student may devote full time to his studies and research, without the necessity of part-time employment in teaching or other work to provide subsistence. Fellowships of various types have been provided by the Westinghouse Educational Foundation, the Allis-Chalmers Manufacturing Company, the Universal Oil Products Company, the Standard Oil Company of Indiana, and the American Steel Foundries.

During the ten years since the establishment of the Graduate School 163 degrees of Master of Science and 11 degrees of Doctor of Philosophy have been awarded. The present enrollment includes 145 students in day programs, 449 students in evening programs, and 86 students in graduate extension programs. Of the present students, 40 expect to receive degrees in June, 1947—34 master's degrees and 6 doctor's degrees.

All phases of the Institute's activities and facilities have greatly expanded during this same ten-year period and many men of outstanding reputation have developed or joined the staff. This growth may be expected to continue with corresponding expansion of graduate work. As graduate work in additional fields of instruction is expanded and organized into comprehensive programs, advanced degrees will be offered in these fields also. Every effort will be devoted to insuring that the Graduate School does its part in maintaining the all-around development of the Institute.

SAFETY

(Continued from page 22)

attitude and to assume that "accidents are bound to happen."

Industrial concerns have learned that accidents can be prevented by a recognition of the specific mechanical conditions and unsafe acts which lead to them, plus the application of corrective measures. The industrial accident record has been improved greatly wherever that positive attiude has been applied to the problem. There is no reason why the home accident menace should not respond to the same type of attack. Architects, contractors, and manufacturers of home equipment and appliances can do much to improve the safety of dwellings if they will devote as much attention to the known causes of home accidents as they do to appearance. So far, appliance manufacturers appear to have given greater consideration to this field of safety than any of the others mentioned. However, the architect is in a position to do the greatest service in home accident prevention.

The basic design of the typical American home makes it a trap in case of fire. Smoke, gas, and heat from a basement blaze can, and do, rush from cellar to upper floors of the average dwelling so rapidly that victims die in the upstairs rooms before they can escape. There is no reason why homes cannot be constructed to discourage such rapid spread of flames and gases.

By better construction and arrangement, many of the serious falls on stairways could be avoided. Statistics show that a considerable percentage (twenty-three percent in the Cook County Hospital study) of *all* home accidents result from stairway falls. Not all of them can be prevented by safe construction, but observation of American Standards Association safety codes will at least eliminate enough of them to improve the situation considerably.

Other accidents, traceable to heating equipment, exposed hot pipes, stumbling hazards, lack of headroom, faulty electrical installations, etc. could be prevented by more safety-minded forethought on the part of the architect or builder who had control over the original specifications.

This article does not attempt in any way to place all the blame upon the architect or builder for the serious home accident situation. It is well recognized that human errors contribute heavily to the majority of accidents. However, a situation as costly and menacing as this calls for every possible effort on the part of everyone concerned.

American homes can be made more safe with no sacrifice of appearance or utility or cost. Educators are nowadays placing increased emphasis upon the need for training pupils of elementary and secondary schools in safe practices — which is encouraging. Finally, the individual householder can remedy the situation by accepting the simple fact that accidents are not bound to happen.

The home can be as safe, or safer, than the work place and will be when it is realized that unsafe arrangement, disorder, lack of repairs, makeshift tools, and inferior equipment are not only poor economies, but deadly enemies to the American family.

MARGARET MANN

(Continued from page 23)

1900, she was made assistant librarian.

It was in these years, 1897 to 1902, at the library of the University of Illinois, that Miss Mann began specialization within the field of library science, in cataloguing and classification. Dr. Bishop, thinking of Miss Sharp, wrote of Miss Mann. "It is the reward of a great teacher to have a few unusual pupils who carry on and enlarge his own conception of his life work." During her own lifetime, Miss Sharp was able to see this made an actuality by Miss Mann.

Her work in cataloguing and classification brought her to the attention of Edwin Anderson, then librarian of the Carnegie Library at Pittsburgh and, in 1902, he persuaded Miss Mann to come to Pittsburgh to carry on her work there. The Carnegie Library is distinguished among the great libraries of the United States. Under Miss Mann's personal supervision and direction, a classified and annotated catalogue was published. This work was on a large scale, and was carried on in the face of almost insurmountable practical difficulties. The impressive array of volumes, the visual result of Miss Mann's supervisory effort, is still used for review by other libraries. Dr. Bishop wrote of this undertaking by Miss Mann, "She supervised the publication of the classified catalogue of the Carnegie Library of Pittsburgh, which was and remains, one of the finest of its kind."

Miss Mann, while at the Carnegie Library, served under four directors. One of these, Mr. Harrison Carver, had been called to the United Engineering Societies Library in New York. A tribute to her enterprise and ability was Mr. Carver's request to her that she join him in New York in 1919 to assist in merging the various elements of the society libraries into the new organization. The services of these libraries were at the call of a most exacting clientele—engineers who required the most exact and up-to-date data. That Miss Mann succeeded in her assignment is attested by the fact that the United Engineering Societies Library is today foremost in its field.

World War I caused disruption of many European libraries to an extent that seemed almost beyond repair. The rehabilitation of the French libraries was carried on chiefly through American effort and initiative. Leading in this effort were the figures of Sarah Bogle and Mary Parsons. There was established in Paris under their direction, the American Ecole des Bibliothecaires. They sought to bring to the librarians of Europe, particularly France, the work initiated in the American libraries. The pupils were chiefly French, but there was a sprinkling of other Europeans in the classes. Work was conducted in French. In 1924, Miss Mann received an invitation to come to the Ecole in Paris to teach. Her pre-eminence in the field of classification and cataloguing was being recognized not only in her own

(Continued on page 48)

(Continued from page 46)

country but also abroad. The thought of teaching in Paris charmed her, but she could not speak French. Determined to accept this tempting offer, she mastered colloquial French in an incredibly short time and went overseas. That she did a notable service in her teaching, bringing to her subject the sparkling humanism of her own personality, can be attested by the friendships she formed in her classes. Two most interesting years, 1924 to 1926, were spent in France.

In 1926, the University of Michigan determined upon the creation of a Department of Library Science under the direction of Dr. William Warner Bishop and his first choice as a member of his staff was Miss Mann. She was appointed assistant professor of library science in the fall of 1926 and in 1928 was appointed associate professor. This position she held until her retirement as associate professor emeritus in 1938.

Professor Mann came out of retirement to attend a special dinner tendered in her honor at Ann Arbor by the Alumni Association of the Library of Science Department of the University, on the occasion of the founding of a scholarship in her name. The Mann Scholarship Fund was established for the benefit of students in the department.

Professor Mann's philosophy of teaching is expressed in the words of one of her many articles, "The Teaching of Technical Processes," in which she writes, "The transmission of ideas and ideals from one mind to another through the medium of books places the library in a commanding position —commanding because of its unlimited resources, its storehouse of information, inspiration and culture." Her published works and articles number a score. In 1926, the American Library Association, attempting to raise the standards of librarianship, in part by providing new textbooks for use in library schools, commissioned Professor Mann to write the textbook on cataloguing and classification. This work was published in 1930.

Dr. Bishop wrote of Professor Mann, "She combines in an unusual fashion ability as a teacher, forcefulness in presenting her subject, and patience in dealing with those facing a wholly new discipline. She has been a powerful force in producing thoroughly trained librarians."

Professor Mann, in concluding some reminiscences of her early college days at Armour wrote, "What I got out of my work at Armour was a first glimpse in organization." It was this "first glimpse" combined with her initiative and ability that enabled her to carry on work at such great library systems as the University of Illinois, Carnegie, The United Engineering Societies, the Ecole des Bibliothecaires in Paris, and lastly at the library of the University of Michigan.

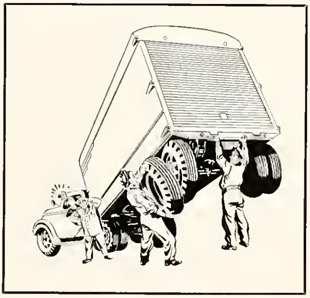
EARL C. KUBICEK

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Nearly a year ago a Revere advertisement dramatized the remarkable lightness of truck bodies made of magnesium alloys by use of a whimsical illustration of a husky chap lifting the rear of a truck while another changed a tire. We at Revere and many other people were amused by what everybody thought was an amusing, but impossibly exaggerated drawing.

However, it was not so exaggerated as we thought. Recently a company making truck bodies of Revere magnesium reported an accident to a truck operated by one of its customers. This is what happened, in the words of the body-builder's letter:



"The truck, fully loaded with bread, was hit by another vehicle and knocked down a ten-foot embankment. The truck turned over on its side prior to hitting the bottom of the embankment.

"Five men righted the fully-loaded truck without using any mechanical devices or levers. Examination of the truck after it was righted revealed only very minor damage to the body structure. The principal damage was scraping of paint and one partially dented side door panel. The truck was returned to service immediately, without repairs.

"After one week of service in this condition, the body was returned to our factory for repairs. Total repair charges were only seven dollars.

"We feel that this example of rugged construction of magnesium bodies and their ability to take severe punishment would be of interest to you."

Revere is indeed interested in this new proof of magnesium's strength, but I find still more significant the fact that five men were able to right that truck. Evidently our whimsical drawing was not so impossible as we thought. Here is a case in which imagination came close to prediction.

Imagination is precious. As this incident illustrates, the "wild" idea of today may turn into an advantageous reality tomorrow. Revere has no monopoly on imagination; every worthwhile company uses it to think of new ways to do old things, or new things to do. So I suggest that no matter what you make, nor from whom you buy materials and parts, you keep an open mind toward suppliers, salesmen, inventors, and your own employees. A good idea can come from almost any source, and may make possible better products at lower costs.

C. Donald Dallas

Chairman of the Board

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices:

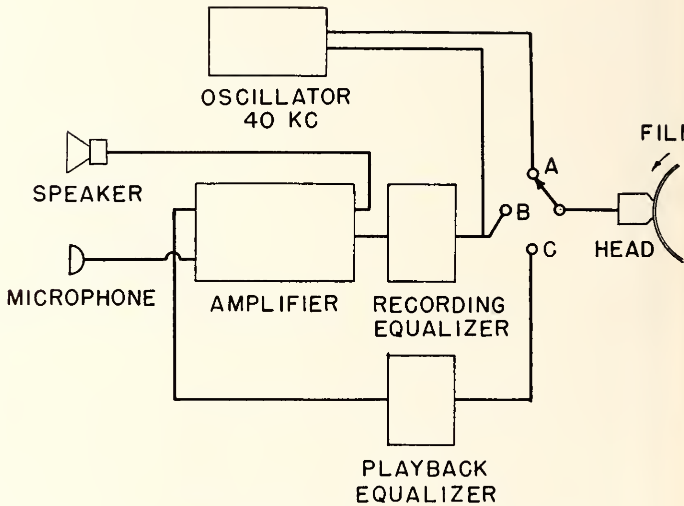
230 Park Avenue, New York 17, N. Y.

ARF

(Continued from page 21)

could, of course, use three heads, which would permit simultaneous erasing, recording and monitoring.

A scanning gap .0007 inch long in the magnetic head should permit a theoretical upper frequency limit of 10,000 cycles. Under special conditions we have been able to record signals of this frequency. At frequencies above 2500 cycles the cumulative effects of gap loss, self demagnetization and head misalignment, cause the response to fall off. At the low frequency end the response drops 6 db per octave. This characteristic can be equalized to give an overall response flat to 5000 or 6000 cycles, which is considered adequate for amateur work.



MAGNETIC SOUND CIRCUITS

A block diagram (Fig. 3) of the recording and playback circuits indicates that erasing is done by means of a 40 kc oscillator when the switch is in position A. In position B the microphone, amplifier, and recording equalizer are in the circuit for recording. Some of the oscillator output is also fed to the record head to provide a high frequency component. In position C the head picks up the magnetic variations in the film. These are first equalized by the playback equalizer; then they are fed through the amplifier and into the speaker.

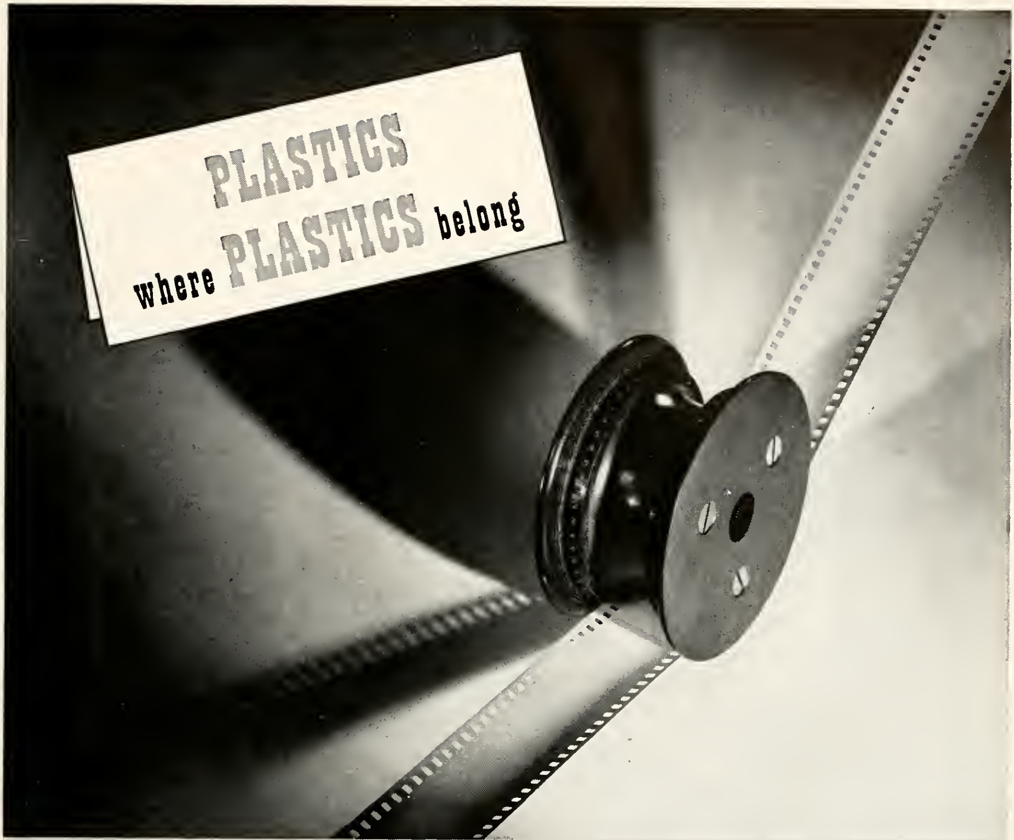
An overall frequency response curve for the 16-mm system shows that it is flat within ± 3 db from 50 to 5000 cycles.

At normal recording levels the intermodulation distortion is about 5%. The background noise is 35 to 40 db below the program level, and there is reason to believe that it can be reduced still further.

The eight millimeter sound system operates at half the speed of the sixteen millimeter apparatus. The sound track is placed between the sprockets and edge of the film, and has the same dimensions as on 16-mm film. Both sides of a double 8-mm film are coated. During processing the pictures are split, and each portion will have its own track. Finished picture film can also have the magnetic material put on, and in this way sound can be added to old films.

In the eight millimeter system, the upper frequency limit of about 2500 cycles gives excellent results on voice, the sibilants being clear and natural. Quality on music, while not as good as at sixteen millimeter speed, is quite comparable with that of many low cost

(Continued on page 52)



Using Corrosion Resistance, Strength, and Machinability

MOVIE FILM carriers are an excellent example of using plastics where plastics belong.

The film carrier illustrated is only one of many types made from Synthane laminated plastics. Synthane is well-suited for the job because it stoutly resists the corrosive action of developing solutions.

The teeth, though small, must be strong and accurately indexed. They are easily milled from Synthane.

Whenever in your future work you have an application for laminated plastics, let us know about it—*before* you design, if possible.

Synthane's help includes design, selection of the right material, and fabrication by men who know plastics. Synthane Corporation, Oaks, Penna.

SYNTHANE TECHNICAL PLASTICS **DESIGN • MATERIALS • FABRICATION**

SYNTHANE

(Continued from page 50)

radio receivers. Distortion and signal to noise ratio are about the same as at higher speeds.

Summarizing the advantages of magnetic sound for amateur work, they are:

1. A magnetic track can be added to any of the conventional films bought by the amateur.

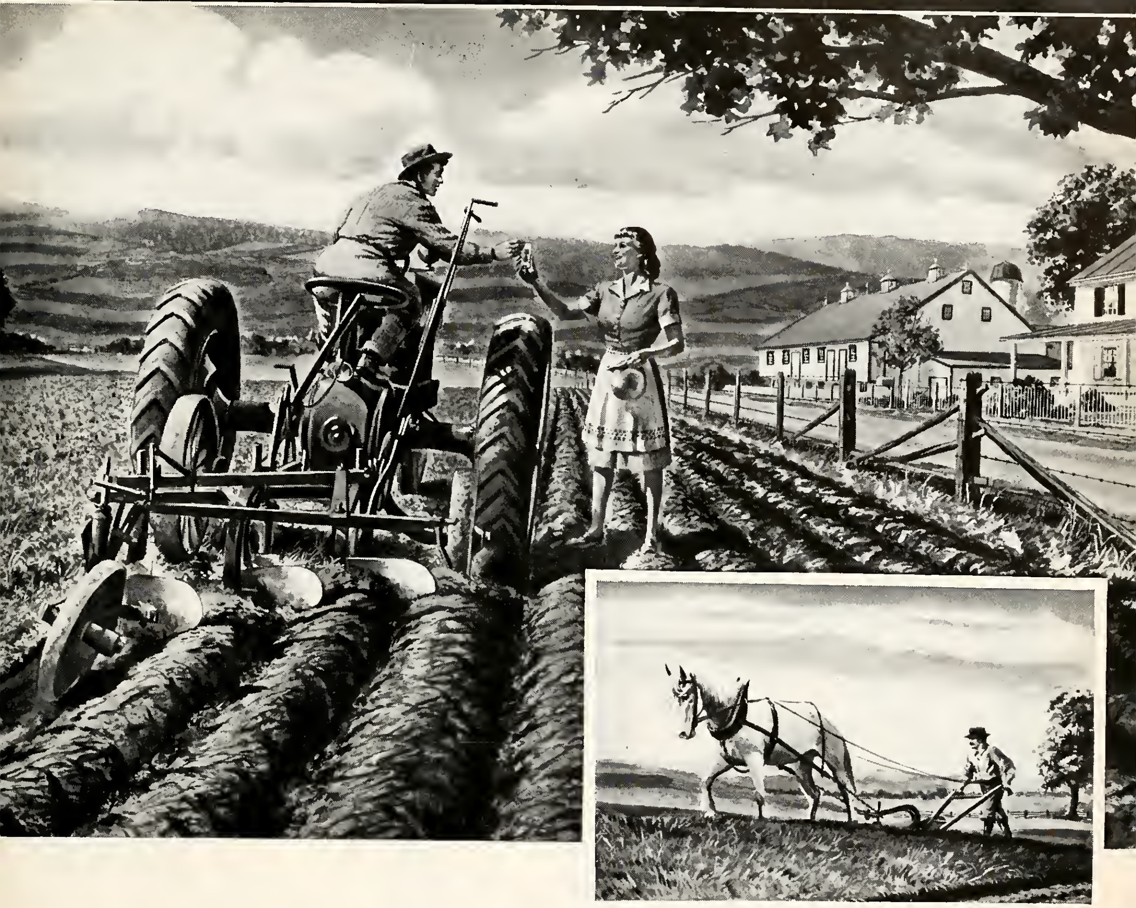
Equipment for recording magnetic sound simultaneously with taking the picture is simpler and less expensive than with optical sound. The magnetic record is not affected by photographic processing.

2. If the original sound track is not satisfactory, any part or all of it may be demagnetized and re-recorded as many times as necessary.

3. A magnetic track can be added to finished film. Anyone who has a library of silent films that were made in the past can send these out, and for a few dollars have a magnetic strip put on. He can then record his own speech and music on such films.

4. For eight millimeter work, magnetic recording gives a flexible and inexpensive sound system for amateur use.

"What is all knowledge . . . but recorded experience?"—CARLYLE



Why some things get better all the time

HEALTH, strength and zest for life—of youngsters, of workers, of all of us—depend on food. Food produced by the millions of tons yearly. And each year our farmers have *more efficient means* to do their tremendous job.

The modern farmer has a tractor, a truck, and uses specialized farm tools—all with parts made increasingly of alloy-toughened steels and of plastics, for sturdier, more efficient service. His milking machine has parts of rust-resistant stainless steel. Chemically fortified feeds grow healthier livestock. New chemical sprays protect his crops from insects and plant diseases. And improved fertilizers restore vital elements to his soil.

From care of the life-giving soil to precious harvest, the farmer's means for food production are steadily improving . . . because into these means go *better and better materials.*

Producing better materials for the use of science and industry and the benefit of mankind is the work of UNION CARBIDE.

Basic knowledge and persistent research are required, particularly in the fields of science and engineering. Working with extremes of heat and cold—frequently as high as 6000° or as low as 300° below zero, Fahrenheit—and with vacuums and great pressures, Units of UCC now separate or combine nearly one-half of the many elements of the earth.

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PRESTONE AND TREK ANTI-FREEZES • ELECTROMET ALLOYS AND METALS • HAYNES STELLITE ALLOYS • SYNTHETIC ORGANIC CHEMICALS

SCHOOLMASTER

(Continued from page 28)

Names may be memorials. In science and in engineering we speak of ohms, volts, amperes, curies, henries. We have both a farad and a faraday. We have the Fridell and Crafts reaction, the Fischer-Tropsch synthesis, the Carnot cycle, the Zeuner diagram, Hookes' law, the Wasserman and Kahn tests, the Geiger counter.

A great book is an explicit memorial to its author. A college, a society, a social reform may be an overt or an implied monument to its founder or perhaps to a successor who has developed and improved upon the work of the founder.

Some of us cannot hope for tangible, visible memorials. What of the physician, whose work may be largely preventive? Who knows how many people would have died of smallpox if Jenner had not lived? How can one evaluate the work of an engineer whose concern has been the promotion of safety. Presumably, if his work has been well and truly done, he has saved scores of lives and millions in property, but it is not provable.

Consider the teacher. He sees with joy the life-work of his students, but he can never know how much of their success is the result of his work. Assuming that he has the decent modesty and the sense of humor that a good teacher must have, he will not consider that each competent and useful graduate of his classes is a two-legged monument to his ability and his schoolmastership.

A man must not deliberately be a builder of a monument to himself. He may and should have satisfaction in a job well done, but his driving force should not be the desire for praise, nor the wish for elaborate commemoration after he has gone. If this commemoration comes, it is well. If not, it is still well, providing that the work is done well and conscientiously. The making of tombstones is not ignoble, but who (other than a Pharaoh) devotes his life to making his own mausoleum?

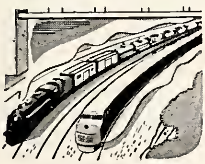
We're not so hot on POGO STICKS

Lots of people like to play jack rabbit. Still, as a way of going to work every morning, we don't see much of a future for Pogo Sticks. Not even *aluminum* Pogo Sticks.

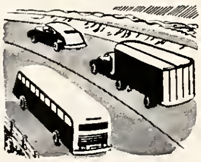
But mention any other means of locomotion or transportation and our aluminum "Imagineers" get a gleam in their eyes. After all, what is more logical than vehicles made of aluminum? Less weight to move. More payload.

We turned our imagination loose on that idea years ago . . . then engineered our thinking into trains, trucks, planes, ships. Alcoa's Development Division has a staff of "Imagineers" who think of nothing else but better ways to transport people, products, and materials by using aluminum. Actually, we have *four separate* staffs of transportation engineers, one each on railroads, highway vehicles, ships and aircraft.

Whatever you do after college, you'll benefit from that. If you go into transportation, these Alcoa engineers will be working with you to cut costs, speed schedules, improve facilities. Or if you choose some field of production, they'll be helping to transport your materials and finished goods cheaper and faster. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

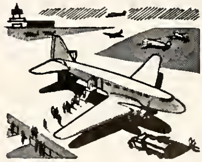


Passenger streamliners, refrigerator cars, hopper cars and tank cars built of Alcoa Aluminum are serving American railroads.



Alcoa Aluminum is finding more and more uses in buses, trucks and trailers. Yes, in passenger car manufacture, too.

Newest thing in shipbuilding is the aluminum superstructure, developed by Alcoa with marine architects and engineers.



Ever since Kitty Hawk, Alcoa has worked with the aircraft industry in developing better aluminum for better planes.

ALCOA FIRST IN ALUMINUM

ALCOA ALUMINUM

CONTRIBUTORS *(Continued from page 4)*

Harvey Curtis Webster, on leave from his position as head of the English department at Fisk University, is visiting lecturer in English literature at Illinois Tech for the year. He has taught at the University of Michigan, Colorado State College, and the University of Louisville and has contributed critical articles, potems, and reviews to such publications as *Poetry, The New Republic, The Sewanee Review,* the Chicago *Sun Book-Week,* and the Louisville *Courier-Journal.* His most recent piece of writing was a fifteen thousand word article on American literature of the past ten years for the *Encyclopaedia Britannica* supplement, *Ten Eventful Years.* The University of Chicago Press will publish his book, *Hardy as Thinker,* in the fall.

Edwin R. Whitehead, Research Professor of Electrical Engineering at the Institute and Consultant in Electrical Engineering to the Armour Research Foundation, received his B.S. degree at the University of Colorado and the M.S. and Ph.D. degrees at the University of Pittsburgh. He has had extended experience in research and teaching. While with the Westinghouse Electric Corporation, he obtained data substantiating the late Dr. C. L. Fortescue's "direct stroke" theory of lightning effects on high voltage transmission lines. Dr. Whitehead is a Fellow of the American Institute of Electrical Engineers, serving actively on its technical committees. He is also a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi honorary fraternities.

E. Clark Woodward is a native of Chicago who engaged in personnel and accident prevention work for ten years prior to World War II. At the outbreak of hostilities, he became associated with the war training activities of Illinois Institute of Technology as director of safety training. After the war, he was associated with the Greater Chicago Safety Council, and recently joined the administrative personnel staff of the O. A. Smith Corporation, Milwaukee, Wisconsin. He has written numerous articles for publications in the accident prevention field, has spoken on safety to many audiences, and is at present the general chairman of the National Safety Council's Power Press Section. He is a member of the American Society of Safety Engineers and of various other safety associations.

GASES

(Continued from page 9)

nitrogen. The temperature is around minus 300 deg. F. This makes it practical to produce a shrinkage of about two thousandths of an inch per inch of diameter with speed, economy, and elimination of cumbersome refrigeration equipment. The cooling apparatus is portable so it may be fitted into assembly line production. Liquid oxygen was formerly used for this purpose, but now it has largely been replaced by liquid nitrogen. Parts may be cooled either by direct immersion in the liquid or by indirect cooling from the cold gas evolved. The gaseous nitrogen evolved not only cools the part but also completely dries it so that no frost forms on the parts as they are being cooled.

In the metallurgical field, nitrogen, either alone or with a small content of hydrogen, is being used for "bright annealing" of wire and certain metal parts where the slightest trace of corrosion would be detrimental.

RARE GASES

The so-called rare gases which total less than one per cent of the atmosphere are chemically inert. Over nine-tenths of this one per cent is argon. All these rare gases are commercially available spectroscopically pure in small glass containers. Argon is also compressed into cylinders similar to those used for nitrogen and oxygen. Helium in a less pure form is also available for industry and medicinal use.

Spectroscopically pure argon, neon, helium, krypton, and xenon find their greatest use in the so-called neon or luminous signs and in the manufacture of a large variety of tubes used in electronics. Selection of a gas mixture for a particular use involves careful consideration and balancing of the physical properties and proportions of these gases to give the proper color of light, conductivity, and wave length.

Argon in larger quantities is used for filling incandescent lamp bulbs because its chemical inertness prevents the tungsten filaments from being consumed. Argon has been substituted for nitrogen for this purpose and adds about twenty per cent to the efficiency.

In the fluorescent lamp of the hot-cathode type, the usual filling pressure is so very far below atmospheric pressure (about four millimeters of mercury) that a surprising volume of fluorescent lamp tubing can be filled from a single liter of gas. Argon and some of the other rare gases can also provide inert atmosphere in certain highly technical metallurgical work where both oxygen and nitrogen must be excluded.

A wartime-developed method of welding, particularly useful for alloy steels and non-ferrous metals, uses important quantities of compressed argon. Electric welding ordinarily requires no cylinder of compressed gas. In this welding process—known as inert-gas-shielded-arc welding—a stream of a monatomic inert gas, usually argon, surrounds a tungsten electrode and keeps the air from contact with the molten metal. The process is widely used for welding the oxidation-resistant metals and alloys including stainless steel, aluminum, magnesium, Inconel, Monel, and Everdur. A particular advantage is that no flux is required so that weld cleaning and finishing is greatly simplified.

OTHER GASES

Space does not permit even limited description of the utility of a variety of other valuable and widely used gases. This group includes ammonia; liquefied petroleum gases; carbon dioxide; chlorine; the anaesthetic gases (cyclopropane, ethylene, nitrous oxide); refrigerant and fumigant gases. All of these are important and the use of these more complex gases is growing daily.

ROCKET

(Continued from page 32)

apparent wave length of atmos approaching is recorded through the other. Comparison with radiation from a stationary source provides measurement of the speed of the atoms and consequently the speed of the rocket blast.

So small is the variation in wave length, Dr. Bundy said, that a spectroscope, normally used in wave length measurement, cannot detect the difference. Instead, a delicate device utilizing mirrored quartz plates, ground and polished close to perfection, transforms the wave lengths into concentric circles on photographic film.

At present, electronic devices are used to record thrust during test firings on the ground. The average velocity of the flame gases can be calculated from the thrust, and the speed and range of the rocket during flight can thus be estimated. Dr. Bundy's measurements will be used as a check against the electronic tests and for more detailed studies of the jet characteristics.

Astronomers in the past have taken the temperature of comets' tails by the method adapted by Dr. Strong to measure the heat of rocket gases. In this test the light of the rocket flame is transformed into a spectrum by means of lenses and prisms. One portion of the spectrum is emitted by hydro-carbon molecules.

The energy released by the molecules is recorded on a special photographic plate, which, after development, is scanned by an intricate photoelectric device known as a microdensitometer which again records its findings in the form of a graph. Correct interpretation of the graph gives the temperature of the rocket exhaust, which, in rockets like the V-2 is approximately 3500° Fahrenheit. The same devices could be used to measure temperatures up to the point of disintegration of the molecules.

The average temperature of the rocket motor exhaust, like the average velocity, can be calculated from other data. Dr. Strong's measurements will constitute important check on these calculations and will make possible more detailed investigation.

BOOKS

(Continued from page 24)

Johnson, Wendell. *People in Quandaries.*

Josephson, Matthew. *Stendahl.* T N

Loeb, Harold. *Full Production Without War.*

MacDonald, Betty. *The Egg and I.* T BBS.

Malaparte, Curzio. *Kaputt.* CS.

Mason, A. T. Brandeis. *A Free Man's Life.* CS N

Mezzrow, Mess. *Really the Blues.* CS

Nehru, Jawahrarlal. *The Discovery of India.* N CT

Northrop, F. S. C. *The Meeting of East and West.* CS T N CT

O'Casey, Sean. *Drums Under the Windows.* T N

O'Neill, Eugene. *The Iceman Cometh.* CT

Orwell, George. *Dickens, Dali and Others.* N T *Animal Farm.* T N CT

The Partisan Reader. Edited by William Phillips and Philip Rahv. N CT

Pearson, Hesketh. *Oscar Wilde: His Life and Wit.* N T

Perkins, Frances. *The Roosevelt I Knew.* T N CT

Pope-Hennessy, Una. *Charles Dickens.* T N

Schorer, Mark. *William Blake: The Politics of Vision.* N

Sheean, Vincent. *This House Against This House.*

Simmons, Ernest J. *Leo Tolstoy.* T N CT

Silone, Ignazio. *And He Hid Himself.*

Sitwell, Osbert. *The Scarlet Tree.* CS T

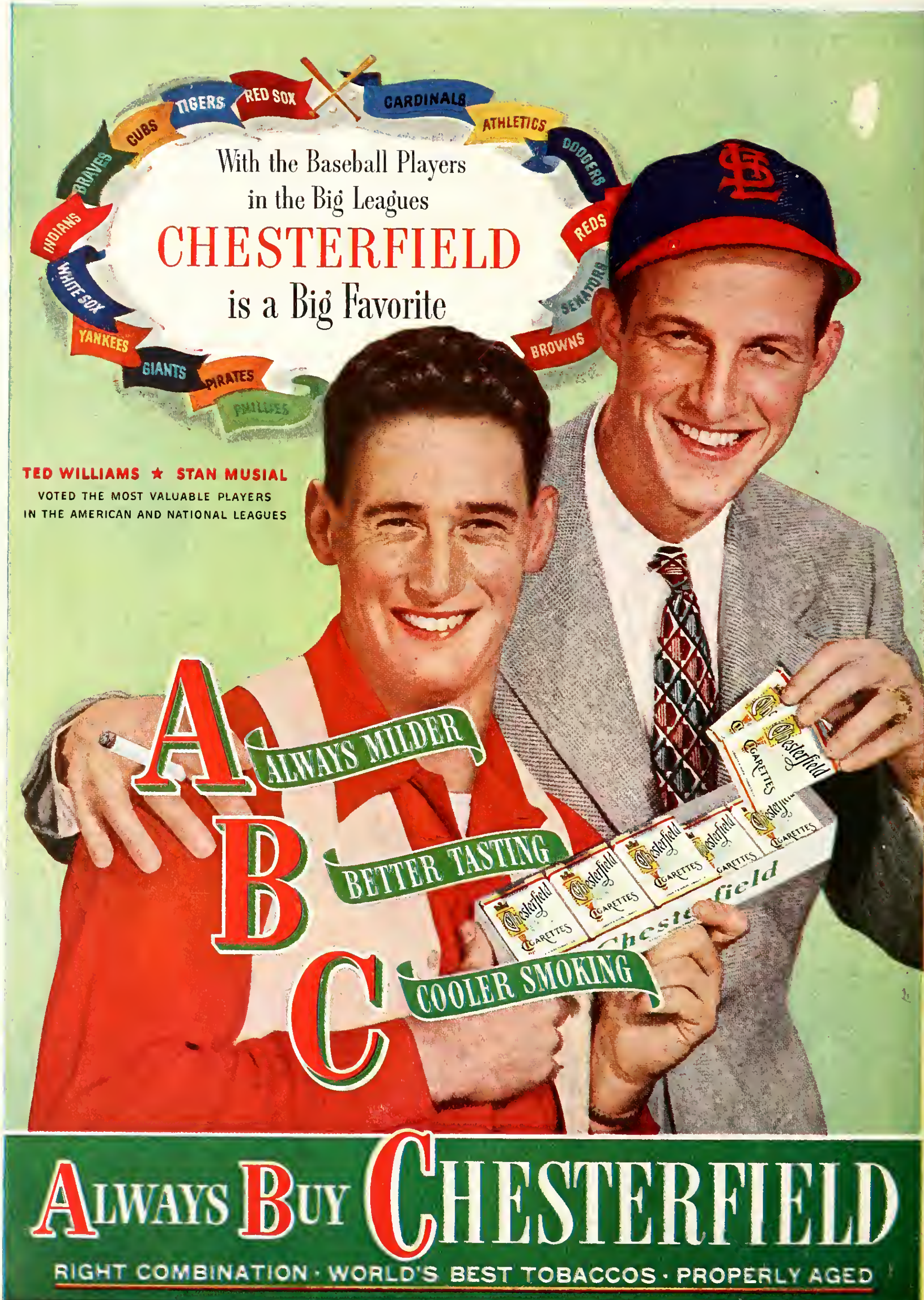
Spender, Stephen. *European Witness* N

Stein, Gertrude. *Brewsie and Willie.* CT

Trotsky, Leon. *Stalin.*

Troyat, Henry. *Firebrand: The Life of Dostoevsky.* N

Zweig, Stefan. *Balzac.* N T


CUBS
TIGERS
RED SOX
CARDINALS
ATHLETICS
DODGERS
BRAVES
INDIANS
REDS
WHITE SOX
SENATORS
YANKEES
BROWNS
GIANTS
PIRATES
PHILLIES
With the Baseball Players
in the Big Leagues
CHESTERFIELD
is a Big Favorite
TED WILLIAMS ★ STAN MUSIAL
VOTED THE MOST VALUABLE PLAYERS
IN THE AMERICAN AND NATIONAL LEAGUES
A ALWAYS MILDER
B BETTER TASTING
C COOLER SMOKING
ALWAYS BUY CHESTERFIELD
RIGHT COMBINATION · WORLD'S BEST TOBACCOS · PROPERLY AGED